# Limestone Industries of Ontario

## Volume I — Geology, Properties and Economics

Ontario

Ministry of
Natural
Resources

Vincent G. Kerrio
Minister

Ministry of
Northern Development
and Mines

Sean Conway
Minister

# LIMESTONE INDUSTRIES OF ONTARIO

## Volume I — Geology, Properties and Economics

- Paleozoic Geology of Ontario
- Precambrian Carbonate Resources
- Properties, Specifications and Uses
- Production, Economics and Markets

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  - *Cornwall District*
  - *Carleton Place District*
  - *Brockville District*
  - *Napanee District*
  - *Tweed District*
  - *Pembroke District*
- Northern Ontario
  - *Espanola District*
  - *Blind River District*
  - *Cobalt District*
  - *Moosonee District*

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  - *Lindsay and Minden Districts*
  - *Huronia District*
  - *Maple District*
  - *Cambridge District*
  - *Niagara District*
- Southwestern Ontario
  - *Owen Sound District*
  - *Simcoe District*
  - *Aylmer District*
  - *Wingham District*
  - *Chatham District*

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# Limestone Industries of Ontario

## Volume I — Geology, Properties and Economics

Prepared for the Aggregate Resources Section,
Land Management Branch, Ontario Ministry of Natural Resources

by
Derry Michener Booth and Wahl
and
Staff of the Engineering and Terrain Geology Section, Ontario Geological Survey,
Ministry of Northern Development and Mines

1989

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The members of the study's steering committee made a valuable contribution to the study by guiding the authors, providing materials and reviewing the report.

A large study such as this is completed only through the efforts of many people. The geological/mining engineering firm, Derry Michener Booth and Wahl, was the lead consultant and was responsible for the plant inventory and descriptions. Staff who prepared the material included David Wahl, Martin Taylor, Wes Roberts and Charles Pitcher, with the assistance of W.G. Wahl, Wahlex Ltd., G. Robert Guillet, Consultant, and Jack Kriens, IMD Laboratories. Don Hains of Hains Technology Associates was responsible for the material on commodities and economics of the limestone industries. Mr. Hains and Mr. W.G. Wahl prepared the plant descriptions for cement, lime and fillers operations.

Staff of the Engineering and Terrain Geology Section, Ontario Geological Survey of the Ministry of Northern Development and Mines prepared the geological description of each site as well as the regional descriptions of the geology of limestone and related carbonate rocks in Volume I. This work was supervised by Dr. Owen White, Chief, Engineering and Terrain Geology Section, and Mike Johnson, Acting Supervisor, Paleozoic/Mesozoic Geology Sub–Section. Staff involved in preparing the site descriptions included Dr. Max Vos, Rainer Wolf, Ruth Bezys, Derek Armstrong, Julie Stevenson–Demeester, Val Mazur, and Chris Fouts. Dr. Peter Telford of the Mineral Development and Lands Branch, Ministry of Northern Development and Mines assisted in the interpretation of geological data and the review of the report.

The project was initiated by the Aggregate Resources Section, Ministry of Natural Resources, under the direction of Dale Scott. Geoff Bell was the project coordinator and report editor.

# Preface

Products from the limestone industries find their way into many of the items that are essential to our modern way of life. In one way or another, the output of the various members of the limestone industries is used in constructing or manufacturing items as diverse as office towers, homes, transportation networks, steel, glass, paper, or rubber products.

This report examines Ontario's limestone industries from two perspectives: the geological resource, including limestone, dolostone, marble and carbonatites; and secondly, the various industries which rely on these resources to manufacture products which are vital to Ontario's economy. These products include construction aggregate, cement, lime, fillers and extenders, building stone and pulverized stone.

In order to undertake a study on such a large and important economic sector, a steering committee was struck to formulate the terms of reference for the study and guide the research and field work through to the report stage. Members of the steering committee were:

☐ Dale Scott, Chairman, Ministry of Natural Resources
☐ Norris Walker, Aggregate Producers' Association of Ontario
☐ Vic Perry, Canadian Portland Cement Association
☐ Don Stonehouse, Energy Mines and Resources Canada
☐ Dr. Owen White, Ministry of Northern Development and Mines
☐ Dr. Peter Telford, Ministry of Northern Development and Mines
☐ Dr. Max Vos, Ministry of Northern Development and Mines
☐ Mike Johnson, Ministry of Northern Development and Mines
☐ Zoltan Katona, Ministry of Transportation
☐ Chris Rogers, Ministry of Transportation
☐ Geoff Bell, Executive Secretary, Ministry of Natural Resources

The study brings together the most up to date geological information pertaining to carbonate rocks and describes the current operations of the members of the limestone industry. In addition, information on the economics of the various commodities is presented in order to give a more complete picture of this resource activity. Field work and data compilation were performed in 1986 and 1987. The authors have attempted to incorporate changes in plant design and ownership up until summer 1988.

The geological and plant site descriptions are organized based on the Ministry of Natural Resources administrative districts. This approach was taken to accommodate the multi–commodity nature of the industry, as well as to facilitate review of the material. This format also allows district updates of activity to be produced easily at a future date.

Metric units are used in the geological descriptions throughout the report, and in parts of the plant and operations descriptions. Since plant equipment is normally sized in Imperial units, these measurements have not been converted to metric units for ease of presentation.

# Contents

**Introduction** . . . . . . . . . . 1

**Part 1 Paleozoic Geology of Ontario** . . . . . . . . . . 3
Summary . . . . . . . . . . 4
  The Michigan Basin . . . . . . . . . . 4
  The Appalachian Basin . . . . . . . . . . 4
  The Algonquin Arch . . . . . . . . . . 4
  The Frontenac Axis . . . . . . . . . . 4
Eastern Ontario (Cornwall, Carleton Place, Brockville, Napanee and Pembroke Districts) . . . . . . . . . . 9
  Potsdam Group . . . . . . . . . . 9
  Beekmantown Group . . . . . . . . . . 9
  Ottawa Group . . . . . . . . . . 11
Central Ontario (Huronia, Lindsay, Tweed, and Napanee Districts) . . . . . 14
  Simcoe Group . . . . . . . . . . 14
Niagara Escarpment (Niagara, Cambridge, Huronia, Owen Sound Districts) . . . . . . . . . . 17
  Cataract Group . . . . . . . . . . 17
  Clinton Group . . . . . . . . . . 18
  Amabel and Lockport Formations . . . . . . . . . . 19
  Guelph Formation . . . . . . . . . . 19
Southwestern Ontario (Niagara, Simcoe, Aylmer, Chatham, and Wingham Districts) . . . . . . . . . . 21
  Salina Formation . . . . . . . . . . 21
  Bertie and Bass Islands Formations . . . . . . . . . . 21
  Oriskany Formation . . . . . . . . . . 22
  Bois Blanc Formation . . . . . . . . . . 22
  Onondaga Formation . . . . . . . . . . 22
  Detroit River Group . . . . . . . . . . 22
  Dundee Formation . . . . . . . . . . 23
  Marcellus Formation, Hamilton Group, Kettle Point Formation, and the Port Lambton Group . . . . . . . . . . 23
Northern Ontario . . . . . . . . . . 24
  Northern Lake Huron . . . . . . . . . . 24
  Lake Timiskaming Area . . . . . . . . . . 25
  Hudson Bay/James Bay Lowlands and the Moose River Basin . . . 25
References Cited . . . . . . . . . . 27

**Part 2 Precambrian Carbonate Resources** . . . . . . . . . . 29
Marble . . . . . . . . . . 30
  Kenora . . . . . . . . . . 30
  Thunder Bay . . . . . . . . . . 30
  Sudbury . . . . . . . . . . 31
  Southeastern Ontario . . . . . . . . . . 31
  Central Gneiss Belt, Grenville Province . . . . . . . . . . 31
  Central Metasedimentary Belt . . . . . . . . . . 31
  Renfrew . . . . . . . . . . 32
  Coe Hill . . . . . . . . . . 32
  Carleton Place . . . . . . . . . . 32
  Kaladar . . . . . . . . . . 33
  Westport . . . . . . . . . . 33
Calcite Veins . . . . . . . . . . 34

Carbonatites . . . . . . . . . . 36
    Ontario Deposits . . . . . . . . . . 36
    Firesand River Complex . . . . . . . . . . 36
    Prairie Lake Complex . . . . . . . . . . 36
    Cargill Complex . . . . . . . . . . 36
    Spanish River Complex . . . . . . . . . . 37
Marl . . . . . . . . . . 38
References Cited . . . . . . . . . . 39

**Part 3 — Properties, Specifications and Uses of Limestone Commodities** . . . . . . . . . . 41
Limestone Aggregates . . . . . . . . . . 42
    Sources . . . . . . . . . . 42
    Production Technology . . . . . . . . . . 42
    Stone Specifications . . . . . . . . . . 45
    Other Uses . . . . . . . . . . 51
Cement . . . . . . . . . . 52
    Types of Cements . . . . . . . . . . 52
    Cement Manufacture – Materials . . . . . . . . . . 54
    Cement Manufacture – Technology . . . . . . . . . . 54
    Cement Uses . . . . . . . . . . 60
Lime, Chemical and Metallurgical Stone . . . . . . . . . . 62
    Lime . . . . . . . . . . 62
    Lime Manufacture . . . . . . . . . . 62
    Lime Kilns . . . . . . . . . . 63
    Forms Of Lime . . . . . . . . . . 66
    Lime Hydration . . . . . . . . . . 67
    Lime Specifications . . . . . . . . . . 67
    Uses . . . . . . . . . . 67
Fillers and Extenders . . . . . . . . . . 73
    Ontario Occurrences and Producers . . . . . . . . . . 73
    Extraction and Processing . . . . . . . . . . 74
    Specifications . . . . . . . . . . 76
    Uses . . . . . . . . . . 77
Building Stone . . . . . . . . . . 81
    Definitions of Building Stone . . . . . . . . . . 81
    Properties of Building Stone . . . . . . . . . . 82
    Quarrying Methods . . . . . . . . . . 82
    Hand Quarrying . . . . . . . . . . 82
    Knox Method . . . . . . . . . . 83
    Channelling by Drilling and Broaching . . . . . . . . . . 83
    Wire Saw Method . . . . . . . . . . 83
    Stone Dressing . . . . . . . . . . 83
Pulverized Stone and Stone Chips . . . . . . . . . . 84
    Introduction . . . . . . . . . . 84
    Terrazzo Chips . . . . . . . . . . 84
    White Marble Chips . . . . . . . . . . 84
References Cited . . . . . . . . . . 86

**Part 4 — Production, Economics and Markets for Limestone Commodities** . . . . . . . . . . 87
Limestone Aggregates . . . . . . . . . . 88
    Demand . . . . . . . . . . 88
    Aggregate Supply . . . . . . . . . . 91
    Production Costs . . . . . . . . . . 91
    Prices . . . . . . . . . . 92
    Transportation Costs . . . . . . . . . . 92
    Technological Developments . . . . . . . . . . 93

Cement . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 94
    Ontario Cement Producers . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 94
    Ontario Cement Production . . . . . . . . . . . . . . . . . . . . . . . . . . . . 95
    Cement Demand . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 96
    Cement Trade . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 103
    Cement Prices . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 104
    Cement Production Costs . . . . . . . . . . . . . . . . . . . . . . . . . . . . 106
    Cement Distribution . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 106
Lime, Chemical and Metallurgical Stone . . . . . . . . . . . . . . . . . . . . . 109
    Lime . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 109
    Chemical Process Stone . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 112
    Metallurgical Stone . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 114
Fillers and Extenders . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 116
    Markets . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 116
    Prices . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 117
    Canadian Demand . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 119
    Canadian Developments . . . . . . . . . . . . . . . . . . . . . . . . . . . . 119
Building Stone . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 120
    Building Stone Markets . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 120
Pulverized Stone and Stone Chips . . . . . . . . . . . . . . . . . . . . . . . . 121
    Terrazzo Chips . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 121
    White Marble Chips . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 121
References Cited . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 122

**Appendices** . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **123**
Appendix I Glossary Of Geological Terms . . . . . . . . . . . . . . . . . . . 124
Appendix II Crystallinity Classification . . . . . . . . . . . . . . . . . . . . 128
Appendix III Bibliography . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 129
Appendix IV Inventory of All Known Paleozoic Limestone
    Quarries in Ontario . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 140

# Introduction

Ontario is fortunate in possessing ample resources of limestone and related carbonate rocks, including dolostone, marble and carbonatite. The rocks, which consist primarily of calcium carbonate, have many uses in today's economy. This report examines Ontario's limestone resources as well as the industries which rely on them: crushed stone aggregates; cement; lime, chemical and metallurgical stone; fillers and extenders; building stone; and pulverized stone. These industries supply the materials upon which Ontario's construction and transportation infrastructure rely. In addition, many limestone products are used in industrial processes which manufacture a host of products such as steel, chemicals, paper and composite materials.

This report attempts to capture the many aspects of the resource sector. The geology of Ontario's carbonate rocks has received considerable attention over the last fifteen years. Part 1 of Volume I deals with the geology of Paleozoic limestone formations on a regional scale. Part 1 integrates all the recent interpretation of stratigraphy, lithology and nomenclature. This is particularly important in southeastern Ontario which relies heavily on bedrock aggregates because of a shortage of sand and gravel aggregate. The geology of southeastern Ontario has been analyzed in depth by geologists of the Ontario Geological Survey over the past eight years. The latest interpretation of the bedrock formations is presented. Part 2 describes the geology of marble deposits in southeastern Ontario, and carbonatites in northern Ontario, as well as calcite veins and marl deposits.

Part 3 of Volume I describes the main limestone industries in Ontario. The commodities of the various sectors are examined in light of physical characteristics, processing techniques, end–uses and specifications of products.

Part 4 describes the economics of each of the limestone industries, and deals with factors such as energy and transportation costs, prices, and competing products which determine the viability and competitiveness of the various products. An outlook for the commodities is given.

Volumes II and III of the report describe the geology, plant, processing and products of the active members of the industry. Volume II includes the operations which are located in northern and southeastern Ontario. Volume III examines the sites in south central and southwestern Ontario. The two volumes consist of detailed site–by–site inventories of each operation. The site inventories include a geological interpretation of the exposed rock in the quarry, a description of the operator's quarry operations and stone processing plant, plus a products list and in many instances a plant flowchart. In addition to commercial sites, many sites with important geological features are included in the inventory.

In the almost thirty years since the late Don Hewitt authored the first study of this type (Hewitt, 1960), many changes have taken place in Ontario's economy. The limestone industries have kept pace with this change, achieving higher production rates with lower energy, labour and raw material input. The primary value for the various products manufactured by the limestone industries is currently approaching one billion dollars annually. The limestone industries are positioned to remain a vital segment of Ontario's economy well into the 21st century.

# Part 1
# Paleozoic Geology of Ontario

# Summary

The Paleozoic strata in Ontario occur in a broad arc which stretches from Ottawa and the Quebec border, southwest across the southern peninsula of the province to Windsor (Figure 1.1, Chart, back pocket). Paleozoic rocks also occur to the north along the Bruce Peninsula and across the north end of Lake Huron, and underlie Manitoulin, Cockburn, and St. Joseph islands and the Sault Ste. Marie area. A small Paleozoic outlier also occurs in the Lake Timiskaming area and large areas of the Hudson Bay/James Bay Lowlands are underlain by rocks of Paleozoic and Mesozoic age.

During the Paleozoic era, much of Ontario was covered by a series of inland seas in which sediments were deposited. These sediments are now exposed and include limestones, dolostones, shales and sandstones. Since most of the sedimentary rocks in Ontario are of shallow marine origin, the local conditions at the time of deposition, such as: water depth, salinity, current direction, proximity to shorelines, etc., strongly influenced the type of sediment. Major episodes of subaerial exposure mark the end of each geological time period in Ontario (i.e. Precambrian, Ordovician, Silurian and Devonian).

The distribution of Paleozoic (and Mesozoic) rocks in Ontario can be subdivided into five major regions based on their age and geographic location. These major regions are: eastern Ontario, central Ontario, Niagara Escarpment, southwestern Ontario, and northern Ontario (Figure 1.2). The northern Ontario region includes parts of Manitoulin Island, the Lake Timiskaming area, and the Moose River Basin of the Hudson Bay Lowland.

The Paleozoic strata in southern Ontario possess a shallow southwesterly regional dip and, coupled with erosion, this has resulted in successively younger rocks becoming exposed at the surface to the southwest. From the northeast to the southwest, therefore, the rocks can be described in ascending stratigraphic order, beginning with the Cambro–Ordovician rocks in the northeast and ending with the Upper Devonian rocks in the southwest (Figure 1.3).

Paleozoic sedimentary rocks in the Province were originally deposited as flat–lying units, and most were subsequently subjected to tectonic disruption to varying degrees. Strata west of Kingston dip to the south or southwest at a rate of a few metres per kilometre. Strata east of Kingston, however, have been disrupted by more intensive tectonic processes with displacements across fault zones of up to several hundred metres and beds which display very high–angle dips. The thickness of Paleozoic rocks over the Precambrian basement increases in a southwesterly direction to a maximum of about 1,350 m near Sarnia because of these regional trends (Johnson et al., 1985), and averages about 400 m across the Province. Table 1.1 is a list of average thickness for formations used by the limestone industry.

Major structural elements which affected Paleozoic deposition across southern Ontario are as follows (Figure 1.4):

## THE MICHIGAN BASIN

This approximately circular structure is present because of regional subsidence of the Precambrian basement rocks centred near Napeena, central Michigan state. As the basement subsided, Paleozoic sediments tended to collect and deposit more rapidly in the centre of the basin, increasing the thickness of each unit towards the basin centre.

## THE APPALACHIAN BASIN

This basin is a foreland regional downwarp which parallels the Appalachian Mountains and is centred south of Ontario. Formations deposited under the influence of this feature thicken to the southeast.

## THE ALGONQUIN ARCH

This basement high of Precambrian rocks separates the Michigan and Appalachian basins, forming the spine of the southern peninsula of Ontario. For several intervals during the Paleozoic, this feature was pronounced and therefore some units thin toward the arch or are absent over it. The Findlay Arch is a continuation of this feature south into the United States, and its intersection with the Algonquin Arch in the Chatham area is called the Chatham Sag.

## THE FRONTENAC AXIS

This is another Precambrian high which extends from the Canadian Shield to the St. Lawrence River between Gananoque and Brockville. Unlike the Algonquin Arch, this structure presently exposes Precambrian rocks at the surface. This ridge separates the Paleozoic sediments in eastern Ontario from those in the rest of the province. As the rocks on both sides of the axis are very similar, it probably was not a barrier to deposition during much of the early Paleozoic. Its current position is due partly to uplift along major fault zones which border the arch.

The presence of the Michigan and Appalachian basins and the Algonquin Arch had a major impact on the Paleozoic rocks deposited in southern Ontario, both in terms of the thickness and variability of each rock type and in their present day distribution. Also affecting the deposition of Paleozoic rocks in southern Ontario was the supply of clastic sediments which originated from two

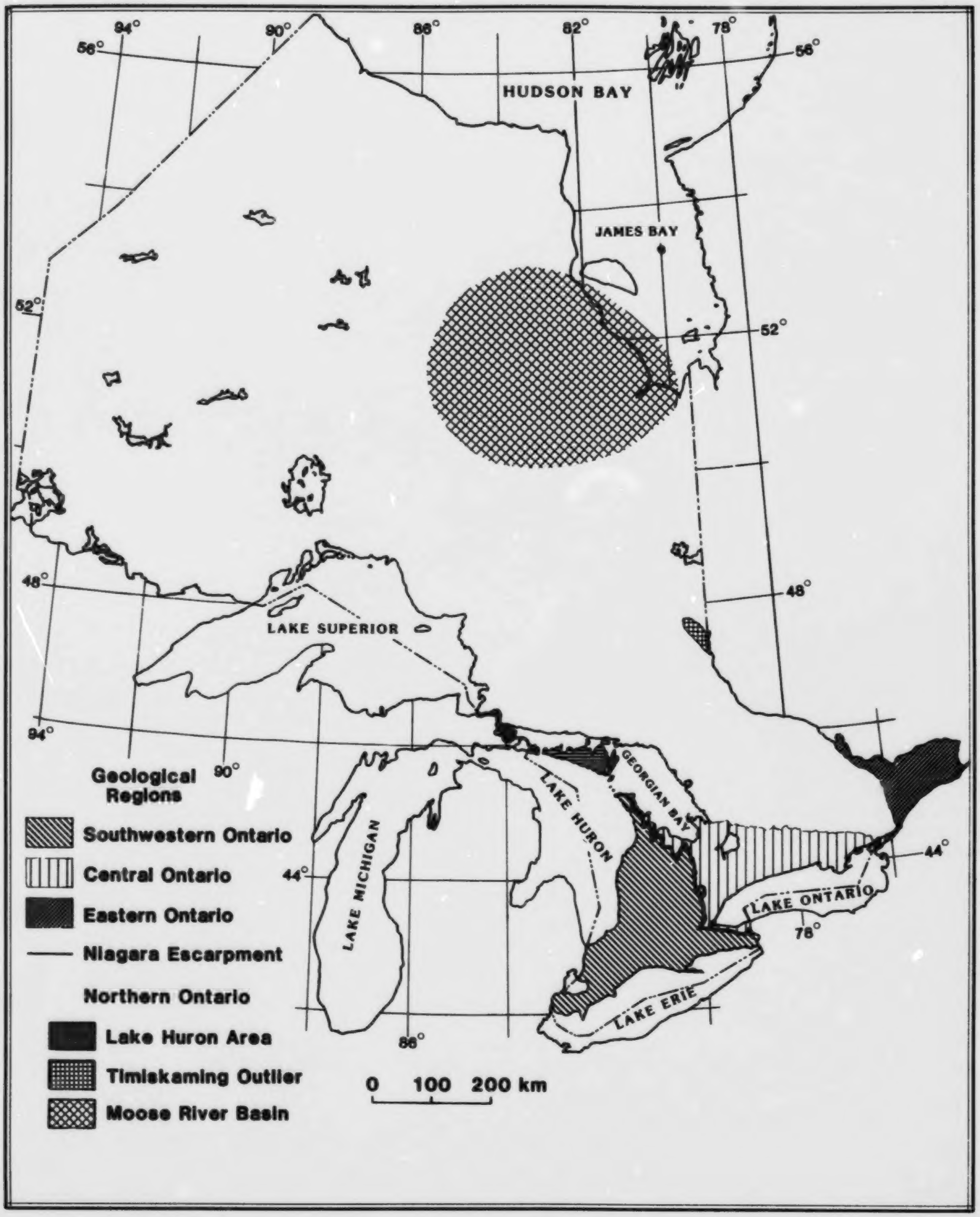

94°
90°
86°
82°
78°
56°
56°
HUDSON BAY
JAMES BAY
52°
52°
48°
48°
LAKE SUPERIOR
94°
90°
Geological Regions
Southwestern Ontario
Central Ontario
Eastern Ontario
Niagara Escarpment
Northern Ontario
Lake Huron Area
Timiskaming Outlier
Moose River Basin
GEORGIAN BAY
LAKE HURON
LAKE MICHIGAN
44°
44°
LAKE ONTARIO
78°
LAKE ERIE
86°
0 100 200 km

Figure 1.2. DISTRIBUTION OF PALEOZOIC ROCKS IN ONTARIO.

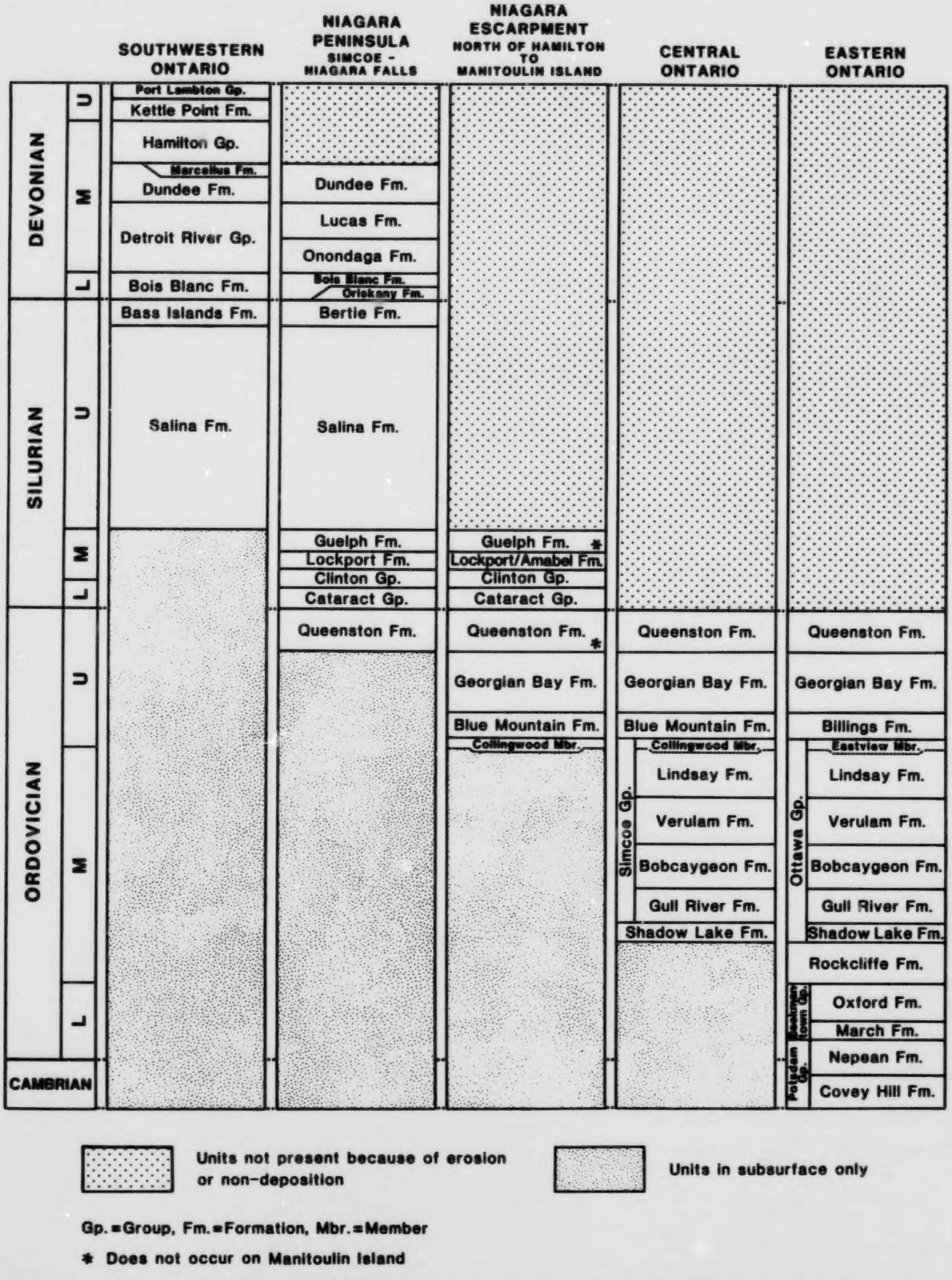
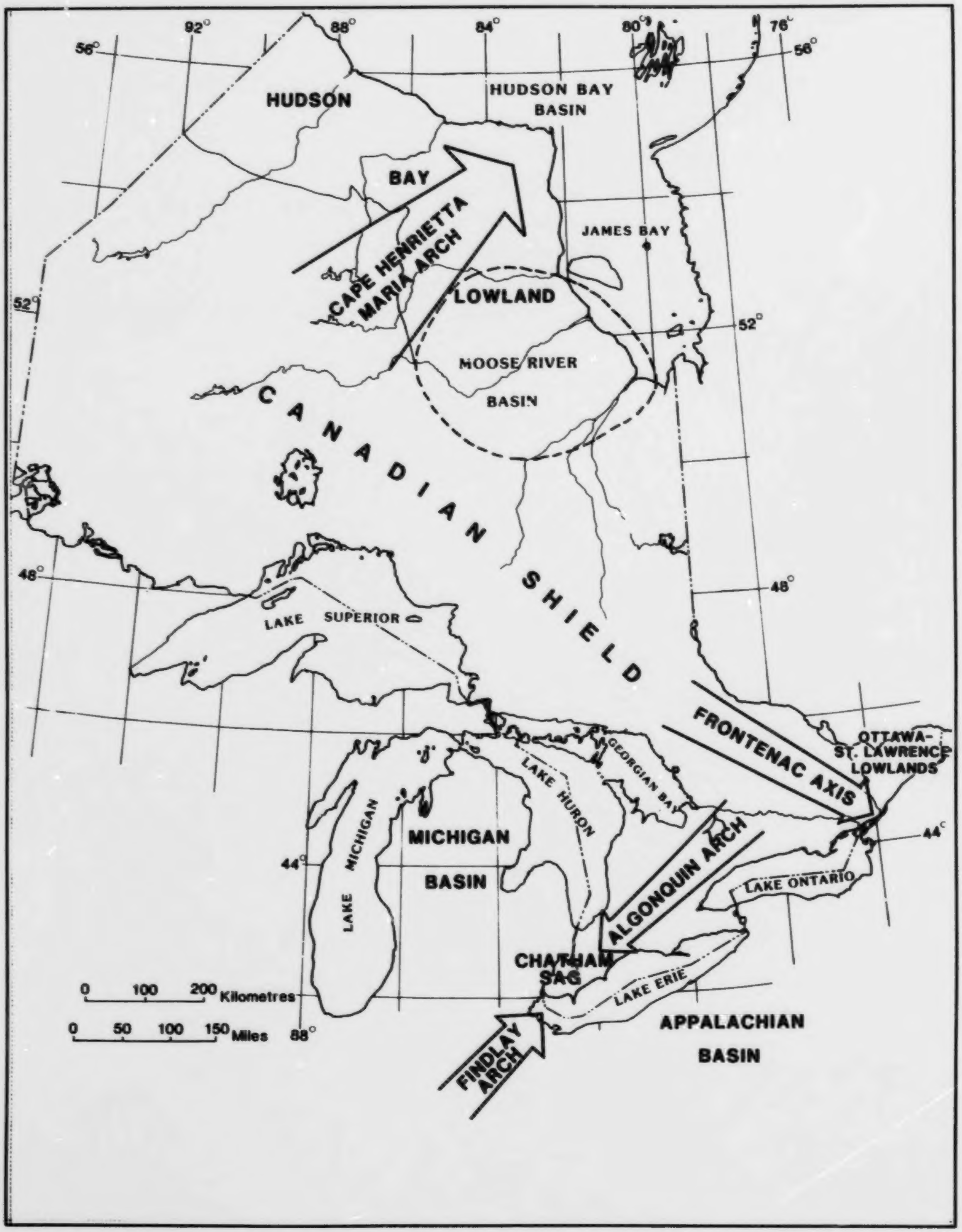

SOUTHWESTERN ONTARIO
NIAGARA PENINSULA SIMCOE - NIAGARA FALLS
NIAGARA ESCARPMENT NORTH OF HAMILTON TO MANITOULIN ISLAND
CENTRAL ONTARIO
EASTERN ONTARIO
DEVONIAN
SILURIAN
ORDOVICIAN
CAMBRIAN
U
M
L
Port Lambton Gp.
Kettle Point Fm.
Hamilton Gp.
Marcellus Fm.
Dundee Fm.
Detroit River Gp.
Bois Blanc Fm.
Bass Islands Fm.
Salina Fm.
Dundee Fm.
Lucas Fm.
Onondaga Fm.
Bois Blanc Fm.
Oriskany Fm.
Bertie Fm.
Salina Fm.
Guelph Fm.
Lockport Fm.
Clinton Gp.
Cataract Gp.
Queenston Fm.
Guelph Fm. *
Lockport/Amabel Fm.
Clinton Gp.
Cataract Gp.
Queenston Fm. *
Georgian Bay Fm.
Blue Mountain Fm.
Collingwood Mbr.
Queenston Fm.
Georgian Bay Fm.
Blue Mountain Fm.
Collingwood Mbr.
Simcoe Gp.
Lindsay Fm.
Verulam Fm.
Bobcaygeon Fm.
Gull River Fm.
Shadow Lake Fm.
Queenston Fm.
Georgian Bay Fm.
Billings Fm.
Eastview Mbr.
Ottawa Gp.
Lindsay Fm.
Verulam Fm.
Bobcaygeon Fm.
Gull River Fm.
Shadow Lake Fm.
Rockcliffe Fm.
Beekmantown Gp.
Oxford Fm.
March Fm.
Potsdam Gp.
Nepean Fm.
Covey Hill Fm.
Units not present because of erosion or non-deposition
Units in subsurface only
Gp.=Group, Fm.=Formation, Mbr.=Member
* Does not occur on Manitoulin Island

Figure 1.3. STRATIGRAPHIC COLUMNS OF PALEOZOIC STRATA IN SOUTHERN ONTARIO.



92°
88°
84°
80°
76°
56°
52°
48°
44°
HUDSON
BAY
LOWLAND
HUDSON BAY BASIN
JAMES BAY
CAPE HENRIETTA MARIA ARCH
MOOSE RIVER BASIN
CANADIAN SHIELD
LAKE SUPERIOR
FRONTENAC AXIS
OTTAWA-ST. LAWRENCE LOWLANDS
GEORGIAN BAY
LAKE HURON
LAKE MICHIGAN
MICHIGAN BASIN
ALGONQUIN ARCH
LAKE ONTARIO
CHATHAM SAG
LAKE ERIE
APPALACHIAN BASIN
FINDLAY ARCH
0 100 200 Kilometres
0 50 100 150 Miles

Figure 1.4. MAJOR STRUCTURAL FEATURES OF PALEOZOIC ROCKS IN ONTARIO.

Table 1.1. AVERAGE THICKNESS OF PRINCIPAL FORMATIONS USED BY THE LIMESTONE INDUSTRY.

| Age | Formation | Thickness (metres) |
|---|---|---|
| Middle Devonian | Dundee | 30 |
| | Detroit River Group | 180 |
| | Onondaga | 20 |
| Lower Devonian | Bois Blanc | 40 |
| Upper Silurian | Bertie | 14 |
| Middle Silurian | Guelph | 30 |
| | Lockport/Amabel | 40 |
| Middle Ordovician | Lindsay | 100 |
| | Verulam | 100 |
| | Bobcaygeon | 70 |
| | Gull River | 45 |
| Lower Ordovician | Oxford | 120 |

sources — the Canadian Shield to the north, and from periodic uplifting of highlands to the east (i.e. the Taconic [ancestral Appalachian] Mountains). The uplift in the east is quite important to some units as the clays and silts introduced had a deleterious impact on the quality of carbonate being deposited.

The discussion which follows will highlight the five regions of Paleozoic strata in Ontario, concentrating on those units which are of significance for use in the limestone industry. For a more complete discussion of the individual Paleozoic formations, refer to the geological introduction of each district and to the individual quarry descriptions found in Volumes II and III.

# Eastern Ontario

## (Cornwall, Carleton Place, Brockville, Napanee and Pembroke Districts)

The Paleozoic bedrock in eastern Ontario (Figure 1.2) is bounded by Precambrian rocks of the Gatineau Hills and the Frontenac Axis to the north and west, respectively. The provincial border delineates the southern and eastern boundary of this area, although Paleozoic rocks extend southward into New York State and eastward into the Province of Quebec.

Sandstones, shales and carbonates of latest Cambrian to latest Ordovician age occur within eastern Ontario. Carbonate rocks which are significant to the limestone industry occur in the Lower Ordovician Beekmantown Group and in the Middle Ordovician Rockcliffe Formation and Ottawa Group (Figure 1.5). The distribution of these rocks in eastern Ontario is complicated by the presence of numerous normal faults (Figure 1.6), some of which may have several hundred metres of displacement (Williams, in prep.), and unlike the Paleozoic rocks west of the Frontenac Axis, there are no regional patterns in the distribution of the rocks in eastern Ontario.

The following discussion of the Paleozoic sequence will focus upon the carbonate rocks. Further details on the geology of the entire sequence can be found in Williams (in prep.).

## POTSDAM GROUP

The Potsdam Group, which forms the basal Paleozoic unit in most of eastern Ontario, consists of the following two formations: the Covey Hill Formation and the overlying Nepean Formation (Figure 1.5). The age of these units may either be Cambrian or Lower Ordovician. Although the Covey Hill and Nepean have been quarried for building stone and crushed stone in the Ottawa area, they are sandstones and thus will not be discussed further in this report.

## BEEKMANTOWN GROUP

Directly overlying the rocks of the Potsdam Group are the dolostones of the Lower Ordovician Beekmantown Group, which is subdivided into the lower March Formation and the overlying Oxford Formation (Figure 1.5). Both units are significantly utilized by the limestone industry, but are found as outcrop only in eastern Ontario although equivalent units are found in the subsurface in southwestern Ontario (Sanford and Quinlan, 1959).

### MARCH FORMATION

The March Formation consists of interbedded quartz sandstone, dolomitic sandstone, sandy dolostone and dolostone. As the sandstones in this unit are indistinguishable from those of the underlying Nepean Formation, the lower contact of the March is placed at the base of the lowest appearance of dolostone beds in the section. Its first appearance is quite variable in different surface exposures because of the variety of facies present within the March Formation. The sandstones consist of fine- to coarse-grained quartz sand, whereas the dolostones are fine to medium crystalline. The intermediate lithologies (sandy dolostones/dolomitic sandstones) have characteristics of both the sandstones and dolostones. Generally the formation is thin to thick bedded, and ranges in thickness from 18 to 20 m in the Ottawa area,

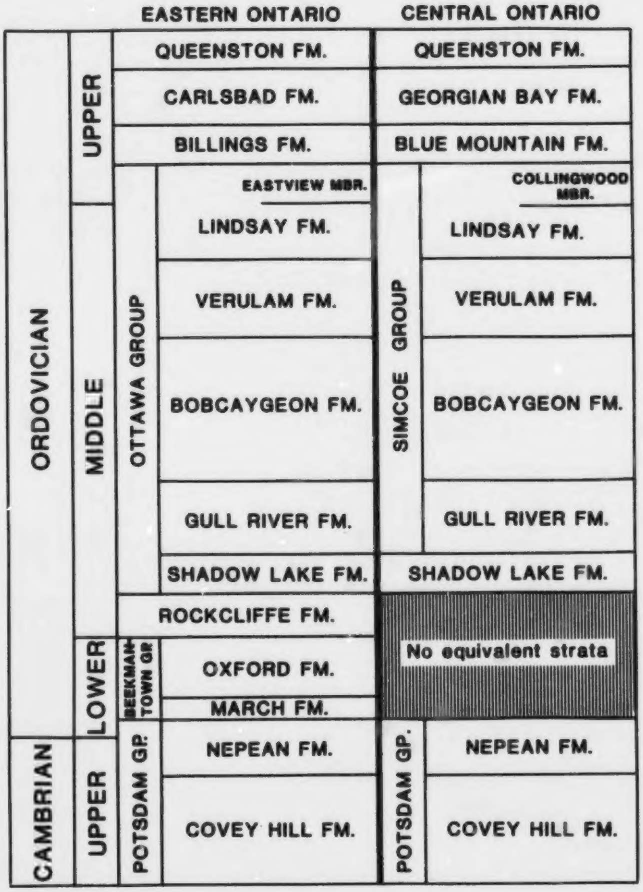

EASTERN ONTARIO
CENTRAL ONTARIO
ORDOVICIAN
CAMBRIAN
UPPER
MIDDLE
LOWER
UPPER
QUEENSTON FM.
CARLSBAD FM.
BILLINGS FM.
QUEENSTON FM.
GEORGIAN BAY FM.
BLUE MOUNTAIN FM.
OTTAWA GROUP
EASTVIEW MBR.
LINDSAY FM.
VERULAM FM.
BOBCAYGEON FM.
GULL RIVER FM.
SHADOW LAKE FM.
SIMCOE GROUP
COLLINGWOOD MBR.
LINDSAY FM.
VERULAM FM.
BOBCAYGEON FM.
GULL RIVER FM.
SHADOW LAKE FM.
ROCKCLIFFE FM.
No equivalent strata
BEEKMANTOWN GR
OXFORD FM.
MARCH FM.
POTSDAM GP.
NEPEAN FM.
COVEY HILL FM.
POTSDAM GP.
NEPEAN FM.
COVEY HILL FM.

**Figure 1.5.** STRATIGRAPHIC COLUMNS OF PALEOZOIC ROCKS OF EASTERN AND CENTRAL ONTARIO.

to 25 m in the Brockville area, and to 64 m in the subsurface near the Town of Alexandria (Williams, in prep.). The highly faulted nature of the rocks east of the Frontenac Axis (Figure 1.6) has caused most of the bedrock exposures of this formation to occur in small, lensoid-shaped fault blocks, usually in proximity to the contact with Precambrian rocks.

## OXFORD FORMATION

The balance of the Beekmantown Group consists of the Oxford Formation (predominantly dolostones), which has a thickness between 62 and 102 m (Williams, in prep.). The dolostones are thin to thick bedded and range from mirocrystalline to medium crystalline. Scattered sand grains and sand interbeds (up to 30 cm thick) appear in the lower part of the formation, and concentrations of chert nodules occur at some localities. The lower contact of the unit is placed where the sand content becomes relatively insignificant (i.e. less than 5% quartz). Most outcrop exposures occur south of Ottawa (Figure 1.6), although some exposures also follow the Ottawa River eastward. These dolostones are extensively quarried in the Brockville area and in a fault block southeast of Ottawa.

## ROCKCLIFFE FORMATION

As originally defined by Wilson (1937) the Rockcliffe Formation, which unconformably overlies the Beekmantown Group (Figure 1.5), consists of interbedded quartz-sandstone and shale. Overlying the Rockcliffe Formation (of Wilson, 1937) is the St. Martin Formation, also defined by Wilson (1937), which is a limestone and silty dolostone. Since these carbonates exhibit shaly and sandy intervals similar to the underlying strata, recent workers (Poole et al., 1970; Williams and Wolf,

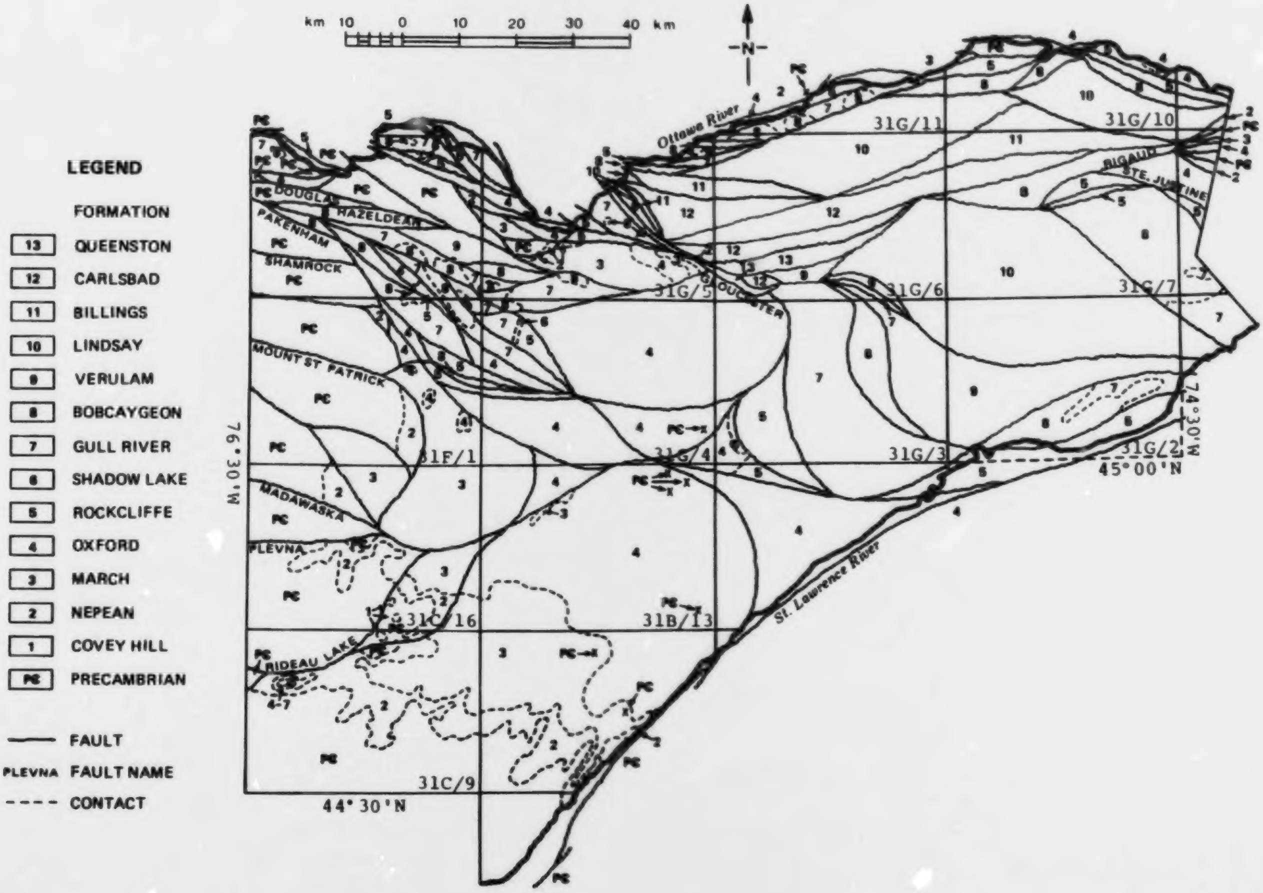

km 10 0 10 20 30 40 km
N
LEGEND
FORMATION
13 QUEENSTON
12 CARLSBAD
11 BILLINGS
10 LINDSAY
9 VERULAM
8 BOBCAYGEON
7 GULL RIVER
6 SHADOW LAKE
5 ROCKCLIFFE
4 OXFORD
3 MARCH
2 NEPEAN
1 COVEY HILL
PC PRECAMBRIAN
FAULT
PLEVNA FAULT NAME
CONTACT
Ottawa River
St. Lawrence River
DOUGLAS
HAZELDEAN
PAKENHAM
SHAMROCK
MOUNT ST PATRICK
MADAWASKA
PLEVNA
RIDEAU LAKE
GLOUCESTER
RIGAUD
STE. JUSTINE
31G/11
31G/10
31G/5
31G/6
31G/7
31F/1
31G/4
31G/3
31G/2
31C/16
31B/13
31C/9
76°30'W
74°30'W
45°00'N
44°30'N

Figure 1.6. MAP OF GENERALIZED PALEOZOIC GEOLOGY OF THE OTTAWA - ST. LAWRENCE LOWLAND.

1982; Williams, in prep.) have combined the two units into the Rockcliffe Formation with the St. Martin Member constituting an upper member of the formation.

The sandstones are light grey to greenish grey, thin to thick bedded and contain abundant sedimentary features such as cross–bedding and burrows. The shales are olive green to dark grey with maroon laminae, whereas the overlying carbonates are light grey to grey–brown and range from microcrystalline to coarse–crystalline. Some of the coarse–crystalline limestones, which are largely restricted to the eastern part of Ontario, are quite high in calcium content. The average thickness for the Rockcliffe Formation is approximately 50 m. Outcrops of the Rockcliffe Formation are restricted and occur mainly along the Ottawa River, or southeast of Ottawa (Figure 1.6). The lower contact of the formation is placed at the lowest occurrence of the sand/shale lithology overlying the dolostones of the Oxford Formation.

Although the lower member of the Rockcliffe Formation (predominantly a sandstone and shale) is not quarried on its own, some quarries have taken material from this unit to be used as general fill. The highly friable nature of this member has limited its use to date, although in recent years several test pits have been excavated to investigate the possible exploitation of the unit. The upper St. Martin Member has been extensively quarried east of the Ottawa area, primarily for aggregate.

## OTTAWA GROUP

Significant changes to the nomenclature and subdivisions of the Middle and Upper Ordovician Ottawa Group (see Figure 1.7) have recently been made by the Ontario Geological Survey (OGS). This was the result of considerable new data generated by recent OGS field mapping of these rocks (Williams, in prep.), in an attempt by the Survey to standardize, as much as possible, the nomenclature used in Ontario.

The Ottawa Group was formerly termed the Ottawa Formation (Wilson, 1946), (Figure 1.7), and subdivided into seven "faunal zone" members. Uyeno (1974) subsequently raised the formation to group status and the members to formation status. Initial OGS mapping in the area by Williams and Wolf (1982) led to the adoption of six lithostratigraphic units, A to F (Figure 1.7). Standardization of this stratigraphy with the sections of Central Ontario (specifically the Lake Simcoe area) was made in 1983 with the adoption by Williams and Rae (1983) of five formations to replace the six lithostratigraphic units previously used. The formations adopted by Williams and Rae (1983) are: the Shadow Lake, Gull River, Bobcaygeon, Verulam and Lindsay

<table>
<tr><th colspan="2">Wilson 1946</th><th colspan="2">Williams and Wolf 1982</th><th colspan="3">Williams and Rae 1983<br>Williams, in prep.</th></tr>
<tr><th>Formation</th><th>"Faunal zone"</th><th>Formation</th><th>Unit</th><th>Gp</th><th>Formation</th><th>Member</th></tr>
<tr><td colspan="2">EASTVIEW</td><td colspan="2">EASTVIEW</td><td rowspan="10">OTTAWA</td><td rowspan="2">LINDSAY</td><td>UPPER (EASTVIEW)</td></tr>
<tr><td rowspan="9">OTTAWA</td><td>"Cobourg"</td><td rowspan="9">OTTAWA</td><td>F</td><td>LOWER</td></tr>
<tr><td>"Sherman Fall"</td><td>E</td><td colspan="2">VERULAM</td></tr>
<tr><td>"Hull"</td><td>D</td><td rowspan="3">BOBCAYGEON</td><td>UPPER</td></tr>
<tr><td>"Rockland"</td><td rowspan="3">C</td><td>MIDDLE</td></tr>
<tr><td>"Leray"</td><td>LOWER</td></tr>
<tr><td rowspan="2">"Lowville"</td><td rowspan="3">GULL RIVER</td><td>UPPER</td></tr>
<tr><td rowspan="2">B</td><td rowspan="2">LOWER</td></tr>
<tr><td rowspan="2">"Pamelia"</td></tr>
<tr><td>A</td><td colspan="2">SHADOW LAKE</td></tr>
</table>

**Figure 1.7. REVISIONS TO THE LITHOSTRATIGRAPHY OF THE OTTAWA GROUP IN EASTERN ONTARIO.**

Formations (in ascending stratigraphic order), (Figure 1.7). In central Ontario these same formations exclude the Shadow Lake Formation and are collectively termed the Simcoe Group. These formations are further discussed in the central Ontario section as there are regional variations between the two.

### SHADOW LAKE FORMATION

The basal unit of the Ottawa Group is the Shadow Lake Formation. In eastern Ontario it consists of silty and sandy dolostone with minor interbeds of sandstone. The dolostones are microcrystalline to fine crystalline, very thin to thick bedded and light green–grey in colour. Up to 2.8 m thick in the Ottawa area, outcrops of this unit are very rare and it is not used by the limestone industry in eastern Ontario.

### GULL RIVER FORMATION

The Gull River Formation in eastern Ontario, which conformably overlies the Shadow Lake Formation, has been subdivided into two members: a lower member consisting of interbedded limestones and dolostones (which may contain some silt or sand); and an upper member consisting of thin–bedded shaly limestones. The formation is about 50 m thick in the Ottawa area and thins eastward to 40 m in the Hawkesbury area (Williams, in prep.). Features common in the Gull River Formation are small lenses of calcite crystals, termed "birdseye" texture, sulphate nodules and molds, and abundant fossils, especially the coral *Tetradium* in the upper member, and stromatolites.

The Gull River Formation outcrops primarily in the Ottawa area although other exposures occur in eastern Ontario especially in the Westport and Cornwall areas (Figure 1.6). This unit is important to the limestone industry and is extensively quarried in the Ottawa and Cornwall areas for crushed stone and concrete manufacturing.

### BOBCAYGEON FORMATION

The Bobcaygeon Formation conformably overlies the Gull River Formation and consists of limestone with planar to undulating shale partings. Three members have been identified within the formation; the middle member is substantially more shaly and resembles closely the overlying Verulam Formation. The lower member is characterized by very thick–bedded, generally microcrystalline limestone beds. The thickness of the Bobcaygeon Formation in eastern Ontario is about 85 m. Within the lower member, black chert nodules up to 20 cm in diameter may be present. This unit occurs throughout eastern Ontario but is most prevalent around Cornwall and Ottawa (Figure 1.6), and is of significant interest to the limestone industry as an aggregate source.

### VERULAM FORMATION

Conformably overlying the Bobcaygeon Formation, the Verulam Formation consists of about 35 m of interbedded limestones and shales. The limestones range from microcrystalline to coarse crystalline, thin to medium bedded and range from light to dark grey or grey–brown in colour. Beds of coarse fossil debris often occur within the limestone beds. The blue–grey, often calcareous shale beds can be up to 15 cm thick and constitute a significant portion of the formation. The distribution of the Verulam Formation is restricted to an area directly southwest of Ottawa (Figure 1.6) and to a larger area in the southwestern part of the Cornwall District. The use of these rocks by the limestone industry is largely restricted to cement manufacture because of their lower purity (i.e. high shale content).

### LINDSAY FORMATION

The Lindsay Formation in eastern Ontario consists of limestone, with thin calcareous shale interbeds, which conformably overlies the Verulam Formation. Identifying the contact between these two units in an outcrop can be difficult, but it is generally placed where the shale interbeds (which characterize the Verulam Formation) become less than 5 cm thick. The Lindsay Formation is divisible into two members; the upper is called the Eastview Member and the lower is unnamed. Portions of the Eastview Member are equivalent to the well known Collingwood shale, an oil shale which is exposed near Craigleith, Ontario. A distinctive characteristic of the limestones of the lower member is the highly undulating nature of the bedding which produces a nodular texture. The limestones are microcrystalline to coarse crystalline, very thin to thick bedded and tend toward grey–brown colours. Shale interbeds are calcareous and dark grey or dark brown in colour. The Eastview Member consists of calcareous shale and exudes a petroliferous odor from a fresh surface. The lower member is extensively used for general aggregate production by the limestone industry. Distribution of the Lindsay Formation is generally restricted to the Cornwall District (Figure 1.6).

### BILLINGS FORMATION

The Upper Ordovician Billings Formation consists mainly of dark grey to black shale, and its lower contact with the Eastview Member of the Lindsay Formation is defined where the shale beds become greater than 2 cm thick. It is considered to be equivalent to the Blue Mountain Formation which occurs in central Ontario. In the Ottawa area (Figure 1.6), the Billings Formation is 62 m thick and consists of non–calcareous to slightly calcareous shale. Minor limestone beds can also be present. This unit is not used by the limestone industry.

### CARLSBAD FORMATION

Conformably overlying the Billings Formation is the Carlsbad Formation, which consists of about 180 m of interbedded blue–grey shale, calcareous siltstone and silty limestone. This unit, while not actively used by the limestone industry, has some potential for cement manufacturing and is equivalent to the Georgian Bay Formation of central Ontario. The contact between the Billings and Carlsbad Formations is defined where the shales change colour from black to blue–grey. Subcrop and outcrop exposures of this unit are restricted to fault blocks which parallel the Ottawa River in the Cornwall District (Figure 1.6).

### QUEENSTON FORMATION

The Upper Ordovician Queenston Formation consists primarily of maroon and olive–grey shales. The thickness of the formation in eastern Ontario is approximately 50 m whereas in southwestern Ontario it reaches up to 120 m. The only surface exposure occurs within a single fault block in the Russell Township area (Figure 1.6). This unit is not used in the limestone industry, but it is widely used by the ceramic and brick industries.

# Central Ontario

## (Huronia, Lindsay, Tweed, and Napanee Districts)

For the purpose of this report, central Ontario encompasses that part of Ontario between the Niagara Escarpment and the Frontenac Axis underlain by Ordovician strata (Figure 1.2), and extends southwards from the exposed Precambrian rocks of the Canadian Shield to Lake Ontario. The Ordovician strata exposed in the northern Lake Huron area are discussed in the northern Ontario section.

The Ordovician rocks of central Ontario range in age from Middle to Upper Ordovician (Figure 1.8), and consist of a sedimentary sequence of carbonates and shales. These strata display a very low regional dip to the southwest which results in successively younger rocks becoming exposed to the west. The base of the Niagara Escarpment, the western boundary of the region, also delineates the Ordovician–Silurian contact.

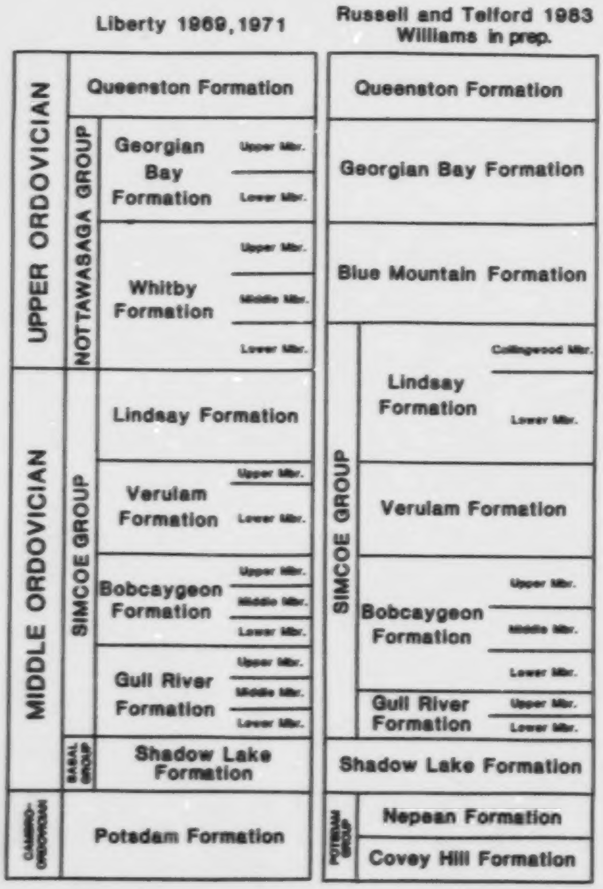

Liberty 1969, 1971
Russell and Telford 1983
Williams in prep.
UPPER ORDOVICIAN
MIDDLE ORDOVICIAN
CAMBRO-ORDOVICIAN
NOTTAWASAGA GROUP
SIMCOE GROUP
BASAL GROUP
POTSDAM GROUP
Queenston Formation
Georgian Bay Formation
Upper Mbr.
Lower Mbr.
Whitby Formation
Upper Mbr.
Middle Mbr.
Lower Mbr.
Lindsay Formation
Verulam Formation
Upper Mbr.
Lower Mbr.
Bobcaygeon Formation
Upper Mbr.
Middle Mbr.
Lower Mbr.
Gull River Formation
Upper Mbr.
Middle Mbr.
Lower Mbr.
Shadow Lake Formation
Potsdam Formation
Queenston Formation
Georgian Bay Formation
Blue Mountain Formation
Lindsay Formation
Collingwood Mbr.
Lower Mbr.
Verulam Formation
Bobcaygeon Formation
Upper Mbr.
Middle Mbr.
Lower Mbr.
Gull River Formation
Upper Mbr.
Lower Mbr.
Shadow Lake Formation
Nepean Formation
Covey Hill Formation

**Figure 1.8.** REVISIONS TO THE PALEOZOIC STRATIGRAPHY OF CENTRAL ONTARIO.

The stratigraphic nomenclature for the Ordovician strata exposed in central Ontario has undergone considerable revision and alteration since the initial surveys of the Geological Survey of Canada in the mid-nineteenth century. The most recent and comprehensive study by Liberty (1969, 1971) provided the basis for the stratigraphic subdivisions used in this report (Figure 1.8). Only minor revisions to Liberty's (1969) original nomenclature have been made, based on recent work by Russell and Telford (1983) and Williams (in prep.). These revisions resulted from the identification of lithological variations apparently not recognized by Liberty (1969), and from extensive drilling undertaken by the OGS (Johnson et al., 1985) since Liberty's (1969) report.

The following discussion summarizes the description of each Ordovician formation present in central Ontario. Further details on local variations in lithologies are described in the district sections in Volume III. Additional information on Ordovician stratigraphy in this area can be found in Liberty (1969) and Williams (in prep.).

### SHADOW LAKE FORMATION

The sediments initially deposited by the Middle Ordovician transgression over the Precambrian basement rocks in central Ontario consist of conglomerates, sandstones and shales, which are up to 12 m thick in some places. These strata are collectively assigned to the Shadow Lake Formation. Older terrigenous rocks may also be present in the subsurface. The Shadow Lake Formation is generally not utilized by the limestone industry of Ontario.

## SIMCOE GROUP

The term Simcoe Group was applied by Liberty (1969) to the Middle Ordovician carbonate sequence in central Ontario. The formations of the Simcoe Group are correlative with those of the Ottawa Group in eastern Ontario (which is also now subdivided into the same formations (Williams, in prep.)).

### GULL RIVER FORMATION

The Gull River Formation, the lowermost carbonate formation in the Simcoe Group, had been subdivided by Liberty (1969) into three members in the Lake Simcoe area and later (Liberty, 1971a–e) into four members in the Kingston area. Based on the recent geological mapping in eastern Ontario (Williams, in prep.), the Gull

River Formation is now considered to consist of two members only. This subdivision can be used for most of central Ontario, except for the extreme western sector west of Lake Simcoe (i.e. Huronia District) where Liberty's (1969) original three–fold subdivision is maintained. Subtle lateral variations in lithology at the base of the Simcoe Group need to be examined in more detail before further revisions are undertaken in this westernmost sector.

The lower member of the Gull River Formation consists of alternating units of limestone and dolostone. The limestones are dominantly microcrystalline, commonly with a lithographic texture, and are interbedded with rare thin–bedded, fine–crystalline intervals. The fine–crystalline dolostones commonly contain small amounts of terrigenous material that ranges from mud to sand sized. This member thickens from 15 m in the west to over 30 m in the Kingston area and is equivalent to the lower member Gull River Formation of Liberty (1969) (Figure 1.8).

The redefined upper member of the Gull River Formation consists of thin–bedded limestones, commonly containing thin shale partings between the beds, and maintains a uniform thickness of 7 to 8 m across the region. It is equivalent to the lower half of the middle member, Gull River Formation of Liberty (1969), (Figure 1.8).

The Gull River Formation has been quarried for many years, especially around Lake Simcoe and Kingston. Stone has been used for aggregate, lime, cement and building purposes, including bridges, town halls and churches throughout central Ontario. Aggregate producers currently utilize most of the rock which is quarried from the Gull River Formation in central Ontario, especially the lower member. Even though some difficulties with alkali–reactivity have been identified (Rogers, 1985), this unit can still be used for a variety of aggregate purposes. The major areas of production are east and west of Lake Simcoe and around the city of Kingston.

## BOBCAYGEON FORMATION

In the Lake Simcoe area the Bobcaygeon Formation had been subdivided into three members by Liberty (1969), whereas in the east only a two–fold subdivision was used (Liberty, 1963; 1971a–e). The Bobcaygeon Formation can now be subdivided into three members across all of central Ontario. The primary distinction between the members is the presence of numerous thin shale partings between the limestone beds in the middle member, while the lower and upper members are virtually shale–free.

The lower member of the Bobcaygeon Formation consists of thick–bedded limestones, with beds usually over 1 m in thickness. The microcrystalline to fine– crystalline limestones are usually intermixed with medium– to coarse–grained calcarenites, and commonly contain nodules of hard, black chert. This redefined lower member of the Bobcaygeon Formation is equivalent to the upper half of the middle member and all of the upper member of the Gull River Formation, as defined by Liberty (1969), (Figure 1.8) and ranges in thickness from about 20 m in the west to about 40 m in the east.

The middle and upper members of the Bobcaygeon Formation are similar to the lower member, except for the higher shale content in the middle member. The thin– to medium–bedded, very fine– to medium–crystalline limestone beds of these members are interbedded with medium– to coarse–grained calcarenites. The upper member may also display a distinctive blue–grey weathered surface. The middle and upper members, as redefined by the OGS, are equivalent to the lower, middle, and upper members of the Bobcaygeon Formation as defined by Liberty (1969), (Figure 1.8).

Outcrops of the Bobcaygeon Formation are rare, relative to the Gull River Formation, although the base of the Bobcaygeon Formation is often exposed as a caprock in some quarries. Where the formation is accessible, the unit is utilized primarily by the aggregate industry. In the past some building stone operations have used material from the lower member.

## VERULAM FORMATION

The term Verulam Formation was applied by Liberty (1969) to a sequence of interbedded limestone and shale which overlies the Bobcaygeon Formation. The Verulam Formation thickens from about 65 m in the west to over 100 m in the east; exposures, however, are isolated because of the thick glacial deposits over most of the area where the formation occurs.

The interbedded nature of the limestone and shale lithologies also makes the formation easily erodable and few natural outcrops remain, although the formation can be examined in quarries and roadcut exposures. The carbonate lithologies vary from very fine–crystalline limestones, virtually fossil–free, to coarse–crystalline, bioclastic limestones. The limestone beds rarely exceed 10 cm in thickness and the 1–5 cm thick interbedded shale is commonly calcareous and burrowed extensively.

The Verulam Formation is rarely utilized by the limestone industry because of its high shale content but in an outcrop area between Belleville and Kingston it is used as a source for aggregate and for cement manufacture.

## LINDSAY FORMATION

The uppermost formation in the Simcoe Group is the Lindsay Formation. Originally defined by Liberty (1969) from exposures around Lake Simcoe, it has subsequently been revised by Russell and Telford (1983), (Figure 1.8). A detailed and widespread drilling program of the upper part of the formation across Ontario by the OGS (Johnson et al., 1983) revealed that the black shale, originally called the Collingwood Shale (Parks, 1928), and assigned by Liberty (1969) to the lower member of the Whitby Formation, can be included with the Lindsay Formation. Its stratigraphic relationship to the under– and overlying strata and its lithology, as determined by geochemical analysis, suggested to Russell and Telford (1983) that this unit was more similar to the Lindsay Formation than Liberty's (1969) Whitby Formation. The balance of the Whitby Formation was renamed the Blue Mountain Formation, reverting to Parks' (1928) original subdivision of these strata.

The Lindsay Formation, as used in this report, can be subdivided into two members: the lower member, a nodular limestone (Liberty's Lindsay Formation), and the upper Collingwood Member, a black calcareous shale (Liberty's lower member, Whitby Formation). The lower member ranges from very fine– to coarse–crystalline nodular limestones with most beds medium crystalline and fossiliferous. On weathered surfaces these thin–bedded limestones commonly exhibit a nodular texture because of very thin, undulating shale partings. The black shales of the overlying Collingwood Member may either overlie the limestones with a minor disconformity, or may be interbedded with the limestones over a thickness of several metres. This member is characterized by black, petroliferous, very calcareous shale which contains a rich fossil assemblage. The Middle–Upper Ordovician boundary occurs near the contact between the lower and upper members of the Lindsay Formation.

The limestones of the lower member range in thickness from 60 m in the west to over 100 m in Prince Edward County, south of the City of Belleville. The black shales of the Collingwood Member maintain a uniform thickness of about 10 m across central Ontario.

The limestones of the Lindsay Formation are used primarily as raw material for the manufacture of cement.

### BLUE MOUNTAIN FORMATION

The Upper Ordovician Blue Mountain Formation (Russell and Telford, 1983) includes the middle and upper members of the Whitby Formation of Liberty (1969). The blue–grey shales of the Blue Mountain Formation outcrop only rarely in the western part of central Ontario and are not used by the limestone industry.

### GEORGIAN BAY FORMATION

The Georgian Bay Formation (Liberty, 1969) is rarely exposed in central Ontario, and where it is exposed the formation consists of interbedded limestone (rarely dolostone) and shale. The formation averages 100 m in thickness and has been subdivided several times into members by various workers (see Liberty, 1969, for a summary). The formation extends across central Ontario southward from Collingwood to underlie a significant portion of Metropolitan Toronto. Thick glacial overburden, limited exposures, and a high shale content limit the usefulness of the formation to the limestone industry, although St. Lawrence Cement Inc. have quarried the rock at their Mississauga plant for use in cement manufacture. Rock from the formation is used in the Toronto area as a raw material for brick manufacturing.

### QUEENSTON FORMATION

The youngest Ordovician strata in central Ontario are the red shales of the Upper Ordovician Queenston Formation. These shales occur below the Niagara Escarpment and extend from the Niagara River west and northward to Georgian Bay in Lake Huron. West of Toronto these shales are used to produce brick and ceramic products.

# Niagara Escarpment

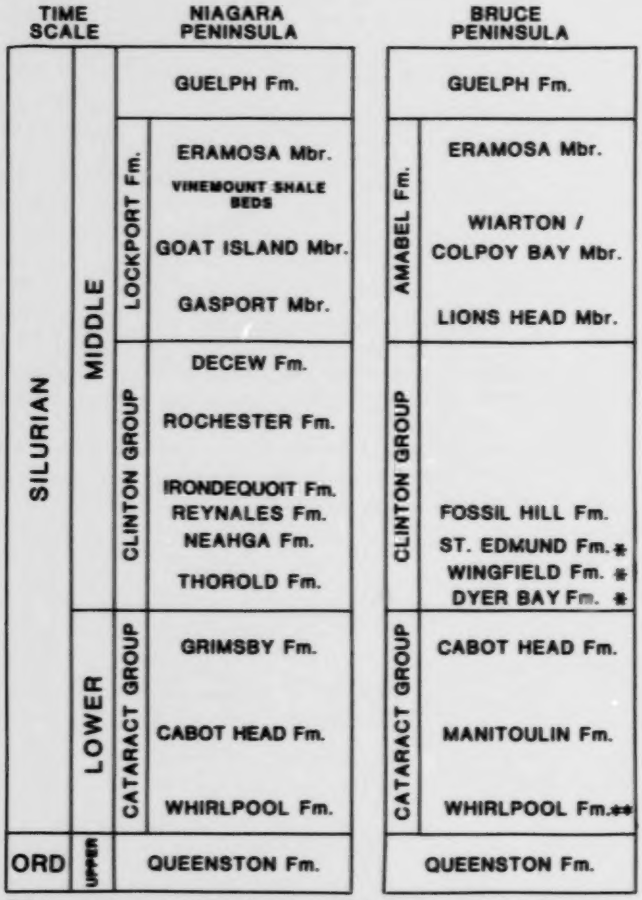
## (Niagara, Cambridge, Huronia, Owen Sound Districts)

The Niagara Escarpment in Ontario extends from the Niagara River Gorge, westward along the Niagara Peninsula to Hamilton, northward to Georgian Bay, northwestward along the Bruce Peninsula, and westward across to Manitoulin and Cockburn islands (Figure 1.2). This erosional feature exposes a Silurian dolostone caprock overlying shales and softer carbonates of Silurian and Ordovician age. The escarpment consists of a series of steep north or northeast-facing cliffs, with the exposed strata dipping gently to the southwest. Except for local lithological variations within the units, the following descriptions are applicable throughout the Ontario portion of the escarpment.

Upper Ordovician strata underlie and form the base of the escarpment throughout most of this region and represent the northerly extent of a wedge of clastic sediments shed from the ancestral Taconic and Appalachian mountains. Silurian age units of the escarpment were deposited under the influence of both the Michigan and Appalachian basins (Figure 1.4). The Silurian strata deposited under the influence of the Appalachian Basin tend to have a higher clastic content, due to their proximity to highland source areas in the east. In northwestern areas adjacent to the Michigan Basin, however, carbonates of higher purity were deposited in predominantly shallow marine shelf and related environments away from clastic sources. Therefore rocks which make up the southern portion of the Niagara Escarpment (Niagara Falls to Milton), tend to contain more terrigenous material than those deposited in the northern portion. These differences have resulted in the application of two sets of nomenclature for the Silurian strata exposed on the escarpment (see Figure 1.9), one each for the northern and the Niagara Peninsula (southern) portions of the escarpment.

Deposition of the rocks exposed on the Niagara Escarpment commenced with the Upper Ordovician Queenston Formation. This was followed by deposition of the Lower Silurian Cataract Group, the Middle Silurian Clinton Group, and culminated with the Middle Silurian Lockport, Amabel and Guelph formations.

The Queenston Formation, which consists mainly of red shales, has been described in the previous section. The Cataract and Clinton groups consist predominantly of sandstones and shales, and are therefore not generally utilized by the limestone industry. The dolostones of the Lockport, Amabel and Guelph formations are of great significance to the limestone industry. Other units, such as the Reynales, Irondequoit and Decew formations, are used only to augment the above formations. More detailed geological discussions are presented in Bolton (1957), Liberty and Bolton (1971), and Sanford (1969) and more recent descriptions by Liberty, Bond and Telford (1976a,b,c), Bond, Liberty and Telford (1976), Bond and Telford (1976), Telford (1976a,b; 1979a,b) and Liberty, Feenstra and Telford (1976a,b).


TIME SCALE
NIAGARA PENINSULA
BRUCE PENINSULA
SILURIAN
MIDDLE
LOWER
ORD
UPPER
GUELPH Fm.
LOCKPORT Fm.
ERAMOSA Mbr.
VINEMOUNT SHALE BEDS
GOAT ISLAND Mbr.
GASPORT Mbr.
CLINTON GROUP
DECEW Fm.
ROCHESTER Fm.
IRONDEQUOIT Fm.
REYNALES Fm.
NEAHGA Fm.
THOROLD Fm.
CATARACT GROUP
GRIMSBY Fm.
CABOT HEAD Fm.
WHIRLPOOL Fm.
QUEENSTON Fm.
GUELPH Fm.
AMABEL Fm.
ERAMOSA Mbr.
WIARTON / COLPOY BAY Mbr.
LIONS HEAD Mbr.
CLINTON GROUP
FOSSIL HILL Fm.
ST. EDMUND Fm. *
WINGFIELD Fm. *
DYER BAY Fm. *
CATARACT GROUP
CABOT HEAD Fm.
MANITOULIN Fm.
WHIRLPOOL Fm. **
QUEENSTON Fm.

*Not present south of Owen Sound **Not present north of Collingwood
Modified after Bolton, Table 1, 1957

Figure 1.9. STRATIGRAPHIC COLUMNS SHOWNING NOMENCLATURE OF LOWER AND MIDDLE SILURIAN UNITS OF THE NIAGARA AND BRUCE PENINSULAS.

## CATARACT GROUP

The Lower Silurian Cataract Group is subdivided into four formations (Figure 1.9) of which only one, the Whirlpool Formation, occurs in both the northern and the Niagara Peninsula (southern) portions of the escarpment. The Manitoulin and Cabot Head formations occur only in the north and the Grimsby Formation is restricted to the southern portion of the escarpment. Because of the generally clastic nature of most of the Cataract Group formations, only the Manitoulin Formation is used by the limestone industry.

### WHIRLPOOL, POWER GLEN, AND GRIMSBY FORMATIONS

The oldest unit of the Cataract Group, the Whirlpool Formation consists of about 8.0 m of quartzose sandstone which becomes thinner to the north. The erosional edge of this unit is reported to be just north of the Duntroon area (south of Collingwood), (Liberty and Bolton, 1971; Telford, 1976a). Overlying the Whirlpool Formation in the Niagara Peninsula are the interbedded shales, limestones, and impure sandstones of the Cabot Head Formation (up to 15 m thick) (Telford and Tarrant, 1975). The Cabot Head Formation is in turn overlain by the Grimsby Formation which is of comparable thickness and consists of interbedded sandstones and shales. The Grimsby Formation is restricted to the Niagara Falls–Milton portion of the escarpment.

### MANITOULIN AND CABOT HEAD FORMATIONS

North of Stoney Creek, the Manitoulin Formation directly overlies the Whirlpool Formation and is equivalent, in part, to the more clastic Cabot Head Formation located on the Niagara Peninsula. The Manitoulin Formation consists of up to 22 m of predominantly thin–bedded, blue–grey to brown dolomitic limestones and dolostones. Although it is locally chert–rich, the Manitoulin Formation where exposed (on Manitoulin Island and on the lower Bruce Peninsula), has good potential as a source of building stone, and presently it is under- exploited. Overlying the Manitoulin Formation are the green, grey, and red shales of the Cabot Head Formation. These shales weather recessively and generally occur at the base of the steep cliffs formed by the overlying resistant dolostones (Lockport and Amabel formations). They are not utilized by the limestone industry.

## CLINTON GROUP

The Middle Silurian Clinton Group has been subdivided into ten formations; some are restricted in their occurrence to either the northern or Niagara Peninsula (southern) portions of the escarpment (Figure 1.9). The oldest units of the Clinton Group are clastic or shaly dolostones and include (in ascending stratigraphic order) the Dyer Bay and Wingfield formations in the north, and the Thorold and Neahga formations on the Niagara Peninsula. The upper units are predominantly dolostones and include (in ascending stratigraphic order) the St. Edmund and Fossil Hill formations in the north, and the Reynales, Irondequoit (a limestone), Rochester (a shale), and Decew formations on the Niagara Peninsula.

### THOROLD AND NEAHGA FORMATIONS

On the Niagara Peninsula or southern portion of the escarpment, the Thorold Formation is a 2 to 3 m thick–bedded quartz sandstone overlain by the Neagha Formation, a black–grey to green shale with minor interbedded limestones.

### DYER BAY, WINGFIELD, AND ST. EDMUND FORMATIONS

At about the same time as the Thorold and Neahga formations were deposited on the Niagara Peninsula, three formations were deposited in the area exposed by the northern part of the escarpment. These northern units consist of (in ascending stratigraphic order) the Dyer Bay, Wingfield, and St. Edmund formations (Figure 1.9), and are restricted to Manitoulin Island and the northernmost portion of the Bruce Peninsula.

The lowest unit, the Dyer Bay Formation, is a highly fossiliferous impure dolostone. Its thickness (only 2 to 4 m) and lack of outcrop exposure have combined to inhibit its development as a building stone. Overlying the Dyer Bay Formation is the Wingfield Formation, a 10 m thick, olive–green to grey shale with dolostone interbeds.

Although not significantly quarried by the limestone industry, the overlying St. Edmund Formation (previously termed the Mindemoya Formation, Liberty, 1968) has potential as an aggregate source. This formation consists of pale grey to brown, micro– to medium–crystalline, thin– to medium–bedded dolostone. Little or no chert is present, although shaly partings are present on some bedding planes. The St. Edmund Formation tends to fracture naturally into brick–sized blocks, a useful attribute when crushing it for aggregate. Currently this unit is only excavated from wayside pits, and is used for general fill and crushed stone for paving. The formation reaches a thickness of about 25 m at the western end of Manitoulin Island, where it is extensively exposed.

### FOSSIL HILL AND REYNALES FORMATIONS

The Fossil Hill Formation overlies the St. Edmund Formation and is seen in the northern portion of the escarpment. This unit is stratigraphically equivalent in part to the Reynales Formation exposed on the Niagara Peninsula portion to the south (Figure 1.9). Both the Reynales and the Fossil Hill formations are dolostones of relatively low purity. The Fossil Hill Formation is a fine– to coarse–crystalline dolostone, and has a high silica content (chert and silicified fossil debris). It is up to 25 m thick on Manitoulin Island and thins southward to 6 m on the Bruce Peninsula.

The Reynales Formation, which overlies the Neahga Formation, is a thin– to thick–bedded shaly dolostone and dolomitic limestone, and is generally less than 3 m thick. The Reynales Formation does not have the high silica content of the Fossil Hill Formation.

Neither the Reynales nor the Fossil Hill formations are excavated individually. Both units, however, are quarried where the overlying Amabel and Lockport formations make extraction economical. The Fossil Hill Formation has good potential for skid–resistant aggregate due to its high silica content.

### IRONDEQUOIT, ROCHESTER, AND DECEW FORMATIONS

South of the town of Waterdown, the Reynales Formation may be overlain by one or all of the following formations: the Irondequoit, Rochester or Decew formations (Figure 1.9). Exposures of the Irondequoit and Rochester formations are extensive, and occur on the escarpment at least as far north as Clappison's Corners (near Hamilton). The Decew Formation, however, is exposed only in the area between the Niagara River Gorge and Ancaster (near Hamilton).

The Irondequoit Formation is a massive, coarse–crystalline, crinoidal limestone with a typical thickness of approximately 2 m. The overlying Rochester Formation is a black to dark grey calcareous shale with numerous limestone lenses, and is called informally the Rochester Shale. Thinning westward from 17.5 m at the Niagara River Gorge, this formation is only 4.2 m thick at Hamilton and pinches out around Clappison's Corners. The Decew Formation consists of sandy to shaly, dolomitic limestones and dolostones and thins westward from a maximum thickness of 4 m at the Niagara River. Although shaly partings are present, the Decew Formation generally occurs as a single bed.

## AMABEL AND LOCKPORT FORMATIONS

Overlying the Clinton Group are rocks of the Middle Silurian Lockport Formation and equivalent Amabel formations (Figure 1.9). Both units are predominantly dolostones with the Lockport Formation clearly recognizable south of Waterdown (near Burlington). North of Waterdown, these dolostones have been assigned to the Amabel Formation which can be traced northwards and westwards into the state of Michigan where it is called the Engadine Dolomite.

The Lockport Formation consists of three formal members and one informal member (in ascending stratigraphic order): the Gasport Member, the Goat Island Member, the informal Vinemount shale beds, and the Eramosa Member. The Eramosa Member forms the upper part of both the Lockport and Amabel formations. The Gasport and Goat Island members are only clearly identifiable as far north as Waterdown. The Gasport Member is typically a thin– to massive–bedded, blue–grey to grey, fine– to medium–crystalline, crinoidal dolomitic limestone of variable thickness but averaging about 6 m. The overlying Goat Island Member consists of massive, irregularly bedded, dark to light grey, fine–crystalline dolostone. Locally it is shaly (Hamilton area), or contains vug–filling mineralization (Niagara Falls area). Chert is strongly characteristic of the Goat Island Member and varies from occasional nodules and lenses (as at Niagara Falls), to such abundance at Hamilton that this zone is informally referred to as the "Ancaster chert beds". The Goat Island Member reaches a maximum thickness of 15.8 m, although the average is closer to 10 m.

The upper portion of the Lockport and Amabel formations is the Eramosa Member which is, in the area between Niagara Falls and the village of Rockwood, a dark brown, fine–crystalline, bituminous dolostone. Dark grey shaly partings are seen in some exposures. North of Rockwood, in the Owen Sound–Bruce Peninsula area, the Eramosa Member exhibits several lithologies. It ranges from very fine–crystalline to sugary, pale buff to almost black, laminated to massive–bedded dolostone, with variable bitumen content and local biostromal development. The Eramosa Member typically emits a strong petroliferous odor when freshly broken. The thickness ranges from 15 m on the Bruce Peninsula to almost 20 m at the Town of Dundas, these variations partly reflecting the discontinuous nature of the unit and partly the difficulty in identifying contacts.

On the Bruce Peninsula, the Amabel Formation has an average thickness of 45 m (at the Town of Wiarton), and is subdivided into the following three members (in ascending stratigraphic order): Lions Head, Wiarton/Colpoy Bay and Eramosa members. The Lions Head Member consists of blocky, dark brown to white, very fine– to fine–crystalline dolostone, with a maximum thickness of 13.7 m (average 4.5 m). The Wiarton/Colpoy Bay Member is a thick–bedded to massive, fine– to coarse–crystalline, blue–grey to white dolostone with abundant crinoidal debris. Bioherms (reefs) and thinner bedded inter–reefal rocks commonly occur within this 23 m thick member, overlain by the Eramosa Member.

South of the Bruce Peninsula these members are not recognizable except for thin–bedded strata in the upper portion of the Amabel Formation (assigned to the Eramosa Member). Southward the Amabel Formation becomes a buff to blue–grey, often mottled, fine– to coarse–crystalline dolostone which is commonly massive bedded, although thin–bedded intervals are occasionally seen. This lithology continues into the Lockport Formation.

The Amabel and Lockport formations are the principal sources of aggregate for the province, particularly in the Milton–Hamilton area. The dolostone is also used for building stone, armour stone, metallurgical flux, and a variety of other purposes.

## GUELPH FORMATION

The Guelph Formation overlies the Lockport and Amabel formations and occurs just west of the Niagara Escarpment in a band trending north from Niagara Falls up to the northern tip of the Bruce Peninsula

(Figure 1.1). The Guelph Formation is not exposed northwest of this area. Lithologically the Guelph Formation is a brown, thick-bedded to massive, porous, sugary dolostone. Massive reefal intervals occur in the formation and are often associated with thinner bedded inter-reefal strata. The thickness of this formation varies from 4 to 50 m. The Guelph Formation is principally used by the limestone industry in Cambridge District (especially around Guelph and Hamilton) as dolomitic lime for metallurgical and flux stone and only rarely as an aggregate source.

# Southwestern Ontario

## (Niagara, Simcoe, Aylmer, Chatham, and Wingham Districts)

The southwestern Ontario region is bounded on three sides by the Great Lakes: Huron, Erie, Ontario, and Lake St. Clair and its eastern side is bounded by the Niagara Escarpment. Paleozoic sediments deposited in this area were influenced by both the Appalachian and Michigan basins with the Algonquin Arch acting as a topographic high between these two basins. The Chatham Sag is present in the extreme southwestern portion of the region where the Algonquin and Findlay arches meet (Figure 1.4). Paleozoic stratigraphic terminology for most of the units are Michigan Basin terms and are applicable throughout most of the region. In the extreme easterly portion of the region (southern Niagara Peninsula), Appalachian Basin terminology is more appropriate (Figure 1.10) (Uyeno et al., 1982; Telford and Johnson, 1984).

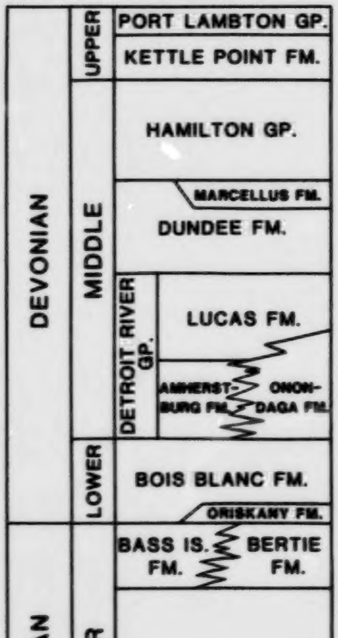


**Figure 1.10. STRATIGRAPHIC COLUMN OF PALEOZOIC ROCKS IN SOUTHWESTERN ONTARIO.**

The Paleozoic stratigraphy of southwestern Ontario consists predominantly of shallow-water platform deposits that range in age from Upper Cambrian to Upper Devonian. The carbonates, clastics and evaporitic units dip gently and show little evidence of structural disturbance (Telford and Johnson, 1984).

Evidence of Cambrian or Lower Ordovician strata is from drill hole information only. These strata represent the initial marine transgression in the southwestern Ontario region and are truncated against the flanks of the Algonquin Arch. Subsequent Middle Ordovician units onlap and overlap the Arch which was a positive topographic feature in early Paleozoic times. Since no Upper Cambrian to Middle Silurian units subcrop in the area, they will not be discussed further.

### SALINA FORMATION

The oldest exposed unit in southwestern Ontario is the Upper Silurian Salina Formation which overlies the Middle Silurian Guelph Formation. The Salina Formation consists of easily weathered argillaceous dolostone, shale and evaporites. A 6 m thick section occurs in a railway and road cutting adjacent to the new Welland Canal, along Townline Road south of Welland. In the subsurface the Salina Formation attains a thickness of approximately 115 to 120 m, and although well known for its evaporite minerals, particularly the extensively mined gypsum and halite (salt) deposits, it is not used presently by the limestone industry.

### BERTIE AND BASS ISLANDS FORMATIONS

The Bertie Formation (in southern Niagara Peninsula) is composed predominantly of resistant dolostones which are exposed in the Onondaga Escarpment (up to 7.6 m in relief), on the Niagara Peninsula. The lower contact of the Bertie Formation with the Salina Formation is gradational, and its upper contact with Devonian age rocks (either the Oriskany or Bois Blanc Formations) is a distinct erosional surface representing a major disconformity. In Ontario the Bertie Formation is represented by five members (in ascending stratigraphic order): the Oatka, Falkirk, Scajaquanda, Williamsville, and Akron members. The lithologies range from shaly dolostones to calcareous dolostones with interbeds of calcisiltites and calcilutites. (See southern Niagara District section, Volume III, for more details on these members.)

Individual members of the Bertie Formation are best seen in the eastern portion of the Niagara Peninsula, since westward, the units pinch out because of the influence of the Algonquin Arch during their deposition. The top of the Bertie Formation is marked by features representing a period of shallowing and subaerial exposure. The Michigan Basin equivalent of the Bertie Formation in the extreme southwestern portion of the region is the Bass Islands Formation. The Bertie Formation reaches a maximum of 14 m in thickness in southwestern Ontario.

The Bertie Formation is an important crushed stone source for the limestone industry, and major operations are located near the towns of Fort Erie, Cayuga, Hagersville, and Dunnville. The Bass Islands Formation is not utilized by the limestone industry.

## ORISKANY FORMATION

The Lower Devonian Oriskany Formation is the oldest Devonian unit in the region. It can be identified with certainty in outcrop at only one locality in Ontario, where it forms the bedrock of an approximately 600 ha area, 10 km east of the town of Hagersville. It is a thick–bedded to massive, coarse–grained, grey–yellow sandstone that disconformably overlies the Silurian dolostones of the Bertie Formation and attains a thickness of approximately 4.5 m. The Oriskany Formation has previously been quarried for silica sand.

## BOIS BLANC FORMATION

The Springvale Sandstone Member forms the basal portion of the Lower Devonian Bois Blanc Formation and consists of medium– to coarse–grained, green, glauconitic sandstone with interbeds of limestone, dolostone, and brown chert. It is discontinuous and is sometimes difficult to distinguish from the Oriskany Formation sandstones.

The Bois Blanc Formation, typically a Michigan Basin unit, is an eastward thinning carbonate wedge which spilled over the Algonquin Arch and interfingered with clastic and carbonate strata of the Appalachian Basin. It is a cherty limestone (excluding the Springvale Sandstone Member) with shaly partings and minor interbedded dolostones, and is very diverse in texture and composition. Fossils are common and the chert can be light grey or brown in colour, and occurs as thin beds or nodules. Toward the centre of the Michigan Basin, the limestones of the Bois Blanc Formation are gradually replaced by grey–brown microsucrosic dolostones, and chert decreases. In the Niagara Peninsula area, the Bois Blanc Formation's thickness may reach 15 m, whereas in southwestern Ontario its thickness reaches approximately 50 m.

The Bois Blanc Formation's upper contact with the overlying Onondaga Formation, on the Niagara Peninsula, is sharp and probably disconformable but, westward towards the Michigan Basin, the contact loses its definition. Outcrops of the Bois Blanc Formation in the southwestern portion of the region are sparse and it is best seen in subsurface drill hole records. On the Niagara Peninsula, the Bois Blanc Formation forms the bedrock in a narrow belt extending west from Fort Erie to Hagersville, and then northwest through Innerkip, Listowel, and Mildmay to Port Elgin on the shore of Lake Huron. Outcrops through these areas are numerous and the unit is often exposed as the caprock of the discontinuous Onondaga Escarpment. Quarry operations have utilized the Bois Blanc Formation near Hagersville, Cayuga and Port Colborne for crushed stone.

## ONONDAGA FORMATION

In the Niagara Peninsula area, the Middle Devonian Onondaga Formation is well exposed. It is an Appalachian Basin unit which has been subdivided into four members (in ascending stratigraphic order): the Edgecliff, Clarence, Moorehouse, and Seneca members. The Edgecliff, Clarence, and the lower part of the Moorehouse Member extend into the Niagara Peninsula of Ontario from New York and can be traced towards the town of Selkirk. Further west, these three members become less distinct and beyond the Port Dover area they grade laterally into limestones and dolostones of the Detroit River Group (a Michigan Basin unit). The members represent a diversity of lithologies which include: bioclastic limestones; biohermal and biostromal limestones; cherty limestones; and argillaceous, fossiliferous limestones. The maximum thickness of this formation is 27 m with reefal mounds sometimes reaching 300 m in diameter.

Member contacts within the Onondaga Formation are gradational, whereas the formation's upper contact with the Dundee Formation is sharp. The Onondaga is quarried around the cities of Welland and Port Colborne for crushed stone.

## DETROIT RIVER GROUP

The Onondaga Formation correlates, in part, with the Middle Devonian Detroit River Group from the Michigan Basin. The two formations in this group are the Amherstburg and Lucas formations (in ascending stratigraphic order) (Figure 1.10). Outcrops of these formations are rare, although they can be seen in quarries located in the Chatham and Aylmer districts. The lower contact of the Amherstburg Formation with the Bois Blanc Formation is difficult to identify and appears to be gradational. The upper contact of the Amherstburg Formation with the Lucas Formation is distinct only in the Woodstock–Ingersoll area.

### AMHERSTBURG FORMATION

The Sylvania Sandstone Member is the basal portion of the Amherstburg Formation. It does not outcrop and only occurs in the extreme southwestern corner of the region (near Amherstburg and Windsor), as reported in drill hole records. It is a strandline deposit consisting of an orthoquartzitic sandstone and overlies the Bass Islands Formation around the western, southern, and southeastern margins of the Michigan Basin. In Essex County, its maximum thickness is 25 m. The Amherstburg Formation (excluding the basal Sylvania Sandstone Member) is a coral/stromatoporoid–rich, bioclastic limestone that is very bituminous and contains grey chert nodules. Its upper contact with the Lucas Formation appears to be conformable with a change from dark coloured, bituminous, coarsely bioclastic limestone (Amherstburg Formation), to a generally light brown micritic limestone (Lucas Formation).

The Formosa Reef Limestone (part of the Amherstburg Formation) is a localized reef development which is approximately 15 m thick and covers about 39,000 ha in Bruce and Huron counties (Owen Sound and Wingham districts). The reefs and bioherms which make up the Formosa Reef Limestones are the remnant surface exposures of large platform reefs that characterized the southeast rim of the Michigan Basin during the deposition of the Amherstburg Formation. The type section for the Formosa Reef Limestone can be seen in a roadcut 4 km north of the village of Formosa. This limestone is of high purity; stromatoporoids were the dominant reef–builders. The maximum thickness of the Amherstburg Formation in the region is approximately 50 m.

### LUCAS FORMATION

The Lucas Formation is well exposed in southwestern Ontario and forms the bedrock of a broad area extending northward from the Ingersoll area to Lake Huron. Excellent exposures of the formation occur in quarries near Amherstburg, Ingersoll, and St. Marys. The Lucas Formation is complex but tends to be an evaporite–rich (halite and anhydrite) dolostone and limestone. Along the rim of the Michigan Basin the formation becomes a platform carbonate deposit of high purity limestone and dolostone.

The Anderdon Member forms the upper portion of the formation but is found only around the rim of the Michigan Basin. The Anderdon Member is usually defined as a high purity limestone (Uyeno et al., 1982). In the quarries around the Woodstock–Beachville area (Aylmer District), the Anderdon Member represents the majority of the Lucas Formation that is exposed (interbedded limestones and calcarenites). In the upper portion of the Stelco Steel quarry (A–4, Aylmer District, Volume III), the Anderdon Member is a sandy limestone which acts as a very distinctive caprock for the quarry face. In subsurface the Lucas Formation can reach thicknesses of approximately 80 m, and is disconformably overlain by the Dundee Formation.

In southwestern Ontario, the Amherstburg and Lucas formations are important to the limestone industry. The high purity limestones of the Lucas Formation are used to produce high–calcium lime for metallurgical processes, and for the manufacture of chemicals. Rock from the Lucas and Amherstburg formations is also used for cement manufacture, agricultural lime, fillers and aggregate.

## DUNDEE FORMATION

The Middle Devonian Dundee Formation is assigned to strata lying between the Detroit River Group and the Marcellus Formation, or the Hamilton Group. Outcrops are not abundant, although extensive exposures occur in the Selkirk–Port Dover area on the Niagara Peninsula; on Pelee Island; in quarries near Amherstburg; and along the Thames and Maitland rivers near the towns of St. Marys and Goderich. Thickness varies from 20 m to 40 m with the best known section occurring in the St. Marys Cement Co. Ltd. quarry (W–1, Wingham District, Volume III).

The Dundee Formation has a relatively uniform lithology: a medium– to thick–bedded, fossiliferous, micritic limestone with occasional brown chert nodules. On Pelee Island, the lower part of the formation is exposed and consists of a massive–bedded, bioclastic limestone. Bituminous laminations are abundant and pockets of bituminous material are generally concentrated in the porous structure of colonial corals. While the upper contact of the Dundee Formation is not exposed, subsurface records indicate lithologies change abruptly from the micritic limestone to the shales of the Marcellus or Bell Formations. The Dundee Formation is used by the limestone industry for cement manufacture, crushed stone, rock dust, chips, and riprap.

## MARCELLUS FORMATION, HAMILTON GROUP, KETTLE POINT FORMATION, AND THE PORT LAMBTON GROUP

The overlying Marcellus Formation, Hamilton Group, Kettle Point Formation, and Port Lambton Group (in ascending stratigraphic order), (Figure 1.10) consist predominantly of grey shales, blue–grey shales, black shales and shaly limestones, respectively, and are rarely utilized by the limestone industry. Uyeno et al., (1982) provide more information on these units.

# Northern Ontario

For the purposes of this report, the northern Ontario region includes all of the Canadian Shield north of the French River that is overlain by Paleozoic rocks (Figure 1.2). This region includes Paleozoic rocks in the northern Lake Huron area (Manitoulin, Cockburn, and St. Joseph islands, and the Sault Ste. Marie area); the northern end of Lake Timiskaming; and the Moose River Basin in the Hudson Bay/James Bay Lowlands. The geology of each of these widely scattered areas is unique and will be discussed separately.

## NORTHERN LAKE HURON

In the northern Lake Huron area, the Silurian strata of Manitoulin and Cockburn islands (Figure 1.11) represent the northernmost extension of the Niagara Escarpment, and trend north– and westward from the Bruce Peninsula in the south. St. Joseph Island is underlain by Ordovician strata, overlain mostly by thick glacial deposits.

### SAULT STE. MARIE AREA

The oldest Paleozoic rocks in this region are the quartz sandstones of either Late Precambrian, Cambrian, or Ordovician age which occur in the Sault Ste. Marie area. Small exposures are present along the shoreline of Lake Superior and along the St. Mary River, and on islands throughout the area. These rocks have been a source of building stone in the past.

### ST. JOSEPH ISLAND

St. Joseph Island is underlain by Ordovician limestones and shales. Immediately overlying the Precambrian surface are conglomerates and sandstones of Cambrian or Ordovician age, some of which are similar to the sandstones which outcrop near Sault Ste. Marie. The Middle Ordovician limestones are superficially similar to the sequence of carbonate rocks which occur in southern Ontario but have not, however, been differentiated into specific formations. The Upper Ordovician is represented by the Collingwood Member (Lindsay Formation), which consists of black, organic–rich, argillaceous limestone; the Blue Mountain Formation, composed of blue–grey shales; and the Georgian Bay Formation, composed of interbedded dolostones, dolomitic limestones and shales (see Russell, 1985, for more detailed information). Much of the island is covered with thick glacial deposits limiting exposure of these formations, and even though this island is the only limestone source in the area, much of what is exposed is rich in terrigenous material that make it unsuitable for a number of applications.

### MANITOULIN AND COCKBURN ISLANDS

Manitoulin and Cockburn islands are northern extensions of the Niagara Escarpment and expose primarily Silurian strata (Figure 1.11), which consist of (in ascending order) the Manitoulin, Cabot Head, Dyer Bay, Wingfield, St. Edmund, Fossil Hill and Amabel formations. The lithologies of these Lower and Middle Silurian units are similar to their descriptions given in the Niagara Escarpment region.

The Ordovician units present on Manitoulin Island and the smaller islands directly to the north include (in ascending order) the Georgian Bay and Blue Mountain

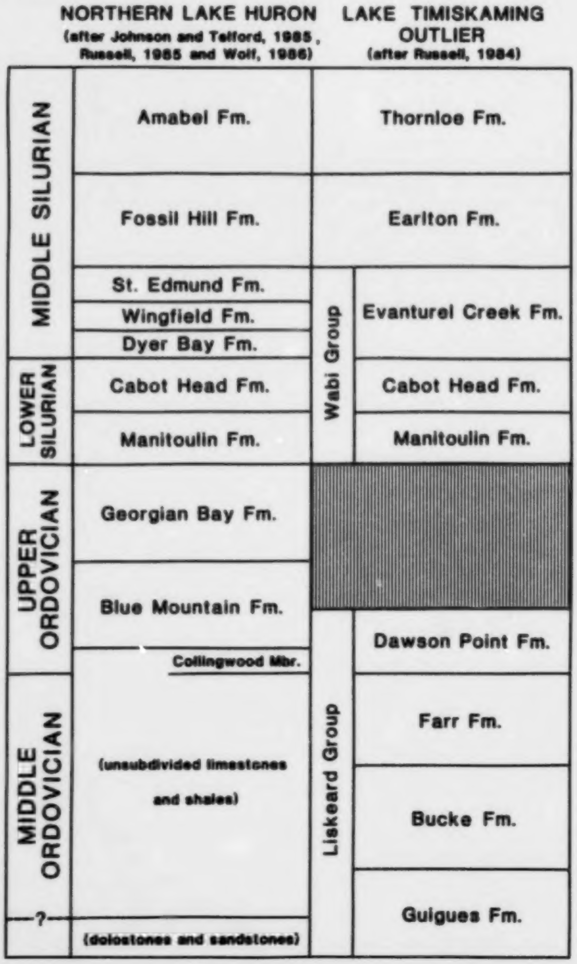

NORTHERN LAKE HURON
(after Johnson and Telford, 1985, Russell, 1985 and Wolf, 1986)
LAKE TIMISKAMING OUTLIER
(after Russell, 1984)
MIDDLE SILURIAN
LOWER SILURIAN
UPPER ORDOVICIAN
MIDDLE ORDOVICIAN
Amabel Fm.
Fossil Hill Fm.
St. Edmund Fm.
Wingfield Fm.
Dyer Bay Fm.
Cabot Head Fm.
Manitoulin Fm.
Georgian Bay Fm.
Blue Mountain Fm.
Collingwood Mbr.
(unsubdivided limestones and shales)
?
(dolostones and sandstones)
Thornloe Fm.
Earlton Fm.
Wabi Group
Evanturel Creek Fm.
Cabot Head Fm.
Manitoulin Fm.
Liskeard Group
Dawson Point Fm.
Farr Fm.
Bucke Fm.
Guigues Fm.

**Figure 1.11. STRATIGRAPHIC COLUMNS OF PALEOZOIC ROCKS IN THE NORTHERN LAKE HURON REGION AND THE LAKE TIMISKAMING OUTLIER.**

formations, and the Collingwood Member of the Lindsay Formation (Figure 1.11). Ordovician strata underlying these units in the subsurface cannot be adequately differentiated using any of the stratigraphic systems presently available. This is similar to the situation on St. Joseph Island.

Bedrock resources on both islands (especially from the Amabel and Fossil Hill formations) are significantly under-utilized by the limestone industry, largely as a result of the distance from suitable markets. Recent quarry developments on Manitoulin Island using ship transportation (see Quarry ES-1, Northern Ontario Region, Volume II), suggest aggregate/flux production will continue and expand. In addition, the St. Edmund Formation is used locally for crushed stone and fill, and the Manitoulin Formation is used for building stone.

## LAKE TIMISKAMING AREA

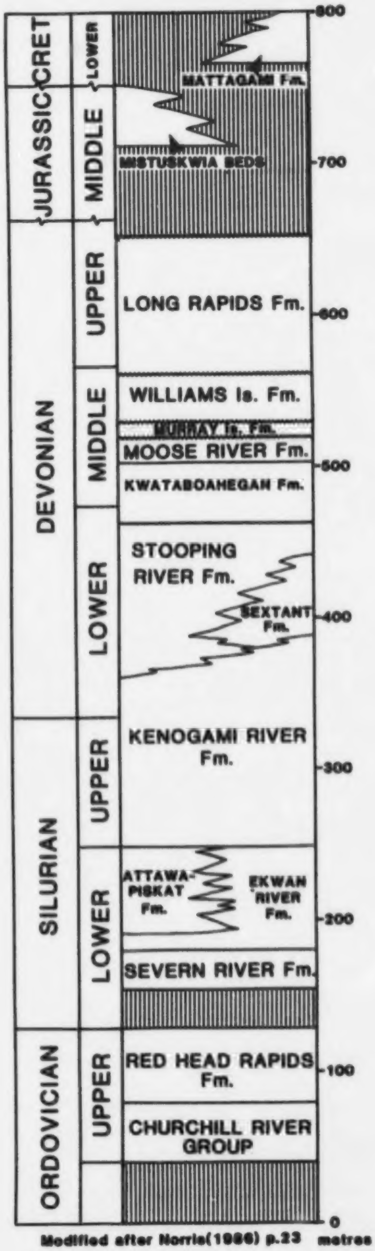
In the Lake Timiskaming area (Figure 1.2), a section of Paleozoic strata has been preserved in a large graben structure. Movements of smaller-scale faults within the graben result in major changes in the geology between adjacent outcrops (a situation which is similar to the Paleozoic geology in eastern Ontario).

The Paleozoic succession in the Lake Timiskaming area includes Orodovician and Silurian strata (Figure 1.11). The Ordovician sequence consists of (in ascending stratigraphic order) the Guigues, Bucke, Farr and Dawson Point formations, and differs significantly from the Ordovician sequence of southern Ontario. The Farr Formation is currently being developed as a source of flux for use in smelting.

The following Silurian units are present in this area (in ascending stratigraphic order) the Manitoulin, Cabot Head, Evanturel, Earlton and Thornloe formations (Russell, 1984). In general the Silurian sequence in the Lake Timiskaming outlier correlates with strata exposed in southern Ontario (compare Figure 1.11 with Figure 1.9); the Thornloe Formation is very similar to parts of the Amabel Formation on Manitoulin Island, and the Earlton Formation is similar to the St. Edmund Formation.

## HUDSON BAY/JAMES BAY LOWLANDS AND THE MOOSE RIVER BASIN

Paleozoic and Mesozoic age strata underlie a broad area (approximately 920,000 sq. km) of northern Ontario called the Hudson Bay Platform. Two-thirds of the platform is under water (Hudson and James Bays) and the remaining third underlies three physiographic regions: the Southampton Plain (Southampton, Coats and Mansel islands) in the north, and the Hudson Bay and James Bay Lowlands in the south. The strata in the Hudson Bay Platform occur in two sedimentary basins, the Hudson Bay Basin in the northwest and the Moose River Basin in the southeast, separated by a northeast-trending feature called the Cape Henrietta Maria Arch (Figure 1.4). While the Hudson Bay Basin is mainly submerged, the Moose River Basin underlies the James Bay Lowland and


JURASSIC
CRET
LOWER
MIDDLE
MATTAGAMI Fm.
MISTUSKWIA BEDS
DEVONIAN
UPPER
LONG RAPIDS Fm.
MIDDLE
WILLIAMS Is. Fm.
MURRAY Is. Fm.
MOOSE RIVER Fm.
KWATABOAHEGAN Fm.
LOWER
STOOPING RIVER Fm.
SEXTANT Fm.
SILURIAN
UPPER
KENOGAMI RIVER Fm.
LOWER
ATTAWAPISKAT Fm.
EKWAN RIVER Fm.
SEVERN RIVER Fm.
ORDOVICIAN
UPPER
RED HEAD RAPIDS Fm.
CHURCHILL RIVER GROUP
800
700
600
500
400
300
200
100
0
metres

Modified after Norris(1986) p.23

Figure 1.12. STRATIGRAPHIC COLUMN OF PALEOZOIC ROCKS OF THE MOOSE RIVER BASIN.

contains some strata of interest to the limestone industry. Unfortunately large areas of the James Bay Lowland are covered by poorly drained muskeg which is dotted by numerous lakes, and therefore information on underlying rock units is confined to scarce river bank outcrops and geological drill holes.

The Moose River Basin is infilled with a Paleozoic and Mesozoic succession which includes Ordovician, Silurian, Devonian, Middle Jurassic and Lower Cretaceous rocks with a total thickness of approximately 760 m. The stratigraphic succession and corresponding lithologies for the Moose River Basin are shown in Figure 1.12. Middle Devonian carbonate units appear to be the most desirable strata for quarrying purposes in the basin and the more attractive units are the Kwataboahegan Formation (see Labelle Quarry, MO–1, Northern Ontario Region, Volume II), the Murray Island Formation, and the upper member of the Williams Island Formation.

The Kwataboahegan Formation predominantly consists of resistant, thick– to massive–bedded, medium–crystalline, biostromal limestone with abundant stromatoporoids and corals. Its Southern Ontario equivalent is the Edgecliff Member of the Onondaga Formation and it is the only unit quarried for stone in the Moose River Basin. The Murray Island Formation is a succession of banded, bituminous, highly calcareous dolostone, fine– to very coarse– crystalline clastic limestone and thin– to medium–bedded argillaceous limestone. It is stratigraphically equivalent to the Dundee Formation in southern Ontario. The Murray Island Formation is disconformably overlain by the Williams Island Formation, which consists of a lower, recessive shale member, and an upper, resistant carbonate member. The upper member consists of thin– to medium–bedded, argillaceous limestones and calcareous shales; medium– to coarse– crystalline saccharoidal and oolitic limestones; and partly brecciated, vuggy, oolitic limestones.

These carbonate units (the Kwataboahegan Formation, the Murray Island Formation and the upper member of the Williams Island Formation) occur in areas of the Moose River Basin which are accessible by the Ontario Northland Railway line and may be potential sources for quarried products.

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# Part 2
# Precambrian Carbonate Resources

Additional carbonate resources for the limestone industries are Precambrian marbles, carbonatites and calcite vein deposits. Minor postglacial marl deposits are also a potential resource.

# Marble

Marble, as used in this report, is defined as a metamorphic rock consisting predominantly of recrystallized calcite and/or dolomite, usually with a granular or saccharoidal (sucrosic) texture. In Ontario, marbles are confined to the Precambrian rocks of the Canadian Shield.

To most of the commercial limestone industries, especially the building stone operators, the term marble is applied to almost any type of crystallized carbonate rock (including true marble, limestone, and dolostone) which is capable of taking a polish and can be used as architectural or ornamental stone. In Ontario, this use includes the "marbles" of the Amabel Formation on the Bruce Peninsula (see Owen Sound District) and the "marbles" of the Gull River and Bobcaygeon Formations of Eastern Ontario (see Cornwall District).

For the purposes of this part of the report, the term marble is only used for metamorphic, recrystallized carbonate rocks. The unmetamorphosed carbonate rocks are referred to by their common geological name, eg. limestone, dolostone, etc.

Marble deposits are identified both in the following text and on Figure 2.1 and Figure 2.2 (Chart, back pocket) according to their geographic distribution, starting in the west and progressing eastward. Deposits are centered in the Kenora, Sudbury, Thunder Bay areas and in southeastern Ontario. Terrazzo (marble chip) quarries in the Madoc area of southeastern Ontario presently account for most of Ontario's marble production. Descriptions of the Madoc operations are included in the quarry descriptions for Tweed District in Volume II, thus they are not discussed in detail in this section.

## KENORA

Marble deposits in the Kenora region include those at Hahn Lake, west of Red Lake and at Woman Lake Narrows, approximately 80 km east of Red Lake.

### HAHN LAKE, RED LAKE AREA

Production of lime in a kiln on the north shore of Hall Bay, Red Lake, was based on marble exposed to the north in a 2.5 km long, 550 m wide belt running north–northeast across Hahn Lake (Figure 2.1 deposit NO–1). This operation was undertaken in the late 1930s. This calcitic marble is intercalated with felsic metavolcanics. White to light grey carbonate forms approximately 25% of the rock in outcrop (Storey, 1986).

### WOMAN LAKE NARROWS, CONFEDERATION LAKE AREA

At Woman Lake Narrows (Figure 2.1, deposit NO–2) a 2.79 billion years old calcitic, stromatolitic marble is exposed. The 100 m thick marble contains minor cherty lenses. The deposit has a strike length of 1.6 km (Storey, 1986). Elsewhere in the area an equally thick older marble is reported with scattered lenses of massive pyrite and pyrrhotite.

## THUNDER BAY

The Rossport Formation in the Thunder Bay area may be divided into three members: (a) lower dolomite, (b) central chert–carbonate (stromatolitic to the north), and (c) upper dolomite. Only when metamorphosed by Keweenawan diabase dikes or sills does the carbonate recrystallize to white dolomitic marble (Speed et al., 1985). Four locations are known where sections of 3 to 6 m of this dolomitic marble constitute a potential resource. The following are the most significant deposits in the Thunder Bay area.

### COOKE POINT, SOUTH SHORE OF LAKE NIPIGON

A quarry was opened at Cooke Point (Figure 2.1, deposit NO–7) for the purpose of producing building and ornamental stone. At the base of a diabase sheet, thin–bedded, gently folded dolomitic limestones, either white or pale green in colour, rise to a height of 6 m above lake level, for about 1.5 km along the lakeshore. A silica content in excess of 20 percent within the limestone is quoted by Pye (see Hewitt, 1964, p.85).

### EAGLE HEAD LAKE, 71 KM NNE OF THUNDER BAY

A quarry for the production of decorative stone from white, brucitic marble and grey, wavy banded dolomitic marble is operated at Eagle Head Lake (Figure 2.1, deposit NO–8) by H. Lundmark and W. McAteer. The 4.5 to 5.5 m thick marble unit is associated with greenish or red carbonate mudstone and overlain by diabase along an irregular contact.

### ITREN LAKE, 69 KM NNE OF THUNDER BAY

A good building and decorative stone material is obtained by H. Lundmark from an exposure of white brucitic marble and grey to multicoloured dolomitic marble on the southwestern shore of Itren Lake (Figure 2.1, deposit NO–9). Associated with purple spotted mudstone and overlain by diabase, the marble attains a maximum thickness of 3 m and is exposed for a strike length of approximately 72 m (Speed et al., 1985, p.84–87).

### WABIKON LAKE, 110 KM NORTH OF THUNDER BAY

White, grey and red calcareous mudstone, intercalated with black shale, is exposed on the west shore of

Wabikon Lake (Figure 2.1, deposit NO–6). A maximum thickness of 3 m of red tinted impure carbonate, grading to white in the vicinity of diabase is exposed. This showing is staked for potential production of decorative building stone (Speed et al., 1985, p.155–158).

## SUDBURY

The Espanola Formation is part of the Huronian Supergroup of metasediments and is the only limestone–bearing formation in the Huronian. Although localized areas are contact metamorphosed to marble, the majority of this unit has remained a limestone in spite of its 2 or more billion year age. The presence of limestone has been reported in several widely spaced locations, suggesting a deposit of large areal extent, eg. Endikai Lake Area (Siemiatkowska, 1978), Benny Area (Card and Innes, 1981), Shining Tree Area (Carter, 1981), Hutton, Parkin, Afton and Clement Townships (Meyn, 1968, 1977). The Espanola Formation is characterized by a lower member rich in carbonate, followed by one or two members with increased sand or silt content. Even in the lower member, siltstone interbeds or sandy limestone or dolostone are common.

The thickness of the Espanola Formation is variable. In the Benny Area the formation ranges in thickness from less than 15 m to over 90 m and averages about 45 m (Card and Innes, 1981, p.59). Elsewhere the formation consists of two more or less equal parts, neither estimated to exceed 60 m in thickness (Meyn, 1968). Development of the Espanola limestone resources north of Lake Huron would be in competition with efficient production from large scale operations in the south that benefit from easy access via Great Lakes shipping (on Manitoulin and Drummond Islands).

## SOUTHEASTERN ONTARIO

Late Precambrian rocks of southeastern Ontario fall within the Grenville geological province. These rocks can be grouped into two major rock types and geographic areas: rocks northwest of a line running northeast between Bobcaygeon and Pembroke are part of the Central Gneiss Belt and consist predominantly of gneissic rocks. Rocks southeast of this line are part of the Central Metasedimentary Belt and consist of mostly clastic rocks. Marble deposits of southeastern Ontario mostly occur in the Central Metasedimentary Belt.

## CENTRAL GNEISS BELT, GRENVILLE PROVINCE

Several marble deposits in the Central Gneiss Belt have been investigated, at one time or another, for production of refractory magnesite (Rutherglen deposits, west of Mattawa (Figure 2.2, NO–23)), calcite filler (Burcal deposits, Huntsville (Figure 2.2, NO–22)) or building stone and lime (Parry Sound area (Figure 2.2, NO– 20, 21)). Satterly (1943) provides a general characterization of the deposits: "Very little pure crystalline limestone occurs, and most of it is speckled with grains of silicate minerals."

## CENTRAL METASEDIMENTARY BELT

Ontario's most extensive marble resources are contained in the Central Metasedimentary Belt of the Grenville Province. In Ontario, a tentative subdivision, based on differences in rock groupings, structural style and metamorphic facies, separates the area of so–called "Grenville Super Group" formations into the Bancroft, Elzevir, Sharbot Lake and Frontenac terrains (Bartlett et al., 1984, p.4). Marble is common in all these terrains but correlation across terrain boundaries is difficult due to the tectonic character of the boundaries. At least two ages of deposition have been established in the Elzevirian terrain where the Flinton Group sediments in the Flinton–Kaladar area represent deposition subsequent to the Elzevirian orogeny (Bartlett et al., 1984, p.5). Locally, as many as four cycles of volcanic activity and carbonate sedimentation have been distinguished in the Belmont–Marmora area (Bartlett et al., 1984, p.9–28).

A statistical analysis of the chemical composition of over 1900 marble samples covering a large part of the Central Metasedimentary Belt is provided by Grant and Kingston (1984).

The respective major marble deposits of the Central Metasedimentary Belt will be discussed according to areas of distribution in the following geographic order: Kinmount, Haliburton, Maynooth, Renfrew, Coe Hill, Plevna, Carleton Place, Kaladar and Westport.

### KINMOUNT, HALIBURTON, MAYNOOTH

Many small deposits are known in this area with a number of small abandoned marble quarries. Geological mapping of the area by Bright (1977) suggests there are several marble units in the area of considerable thickness. The following formation descriptions pertain to the Eels Lake area east of Kinmount:

*(1) Monmouth:* Thickness less than 30 m up to 900 m; limestone and dolostone; minor greywacke siltstone (calcitic to dolomitic marble; minor biotite–rich gneiss).

*(2) Tory Hill:* Thickness less than 30 m up to 1350 m; thinly interbedded limestone, calcareous greywacke, arkosic sandstone, and chert; subordinate tuff (calcitic silicated marble, calc–silicate gneiss, clean quartzofeldspathic gneiss, impure quartzite; minor amphibolite).

*(3) Dungannon:* Thickness 300 m to 1350 m; dolostone and limestone; subordinate calcareous sandstone and siltstone; minor arkosic sandstone, chert and mafic tuff (dolomitic and calcitic marble, calc–sili-

cate gneiss, amphibolite, biotitic quartzofeldspathic gneiss and quartzite).

A graphic display of the geological environment that brings about the alternating sequence of marble, volcaniclastic units and siliceous sediment is given by Easton (1986, p.141–151).

Due to the localized nature of volcanic activity associated with the carbonates, the marbles cannot be regionally correlated.

## RENFREW

Marbles in the Renfrew area (Figure 2.2, NO–27) are derived from impure limestone and dolostone (Lumbers, 1982, p.19). Calcitic and dolomitic marbles are distinguished by Lumbers into relatively pure varieties and those with substantial siliceous impurities, though these units are frequently intercalated.

Marbles in the Renfrew area are predominantly coarse crystalline and occasionally, in highly strained structural zones, very coarse crystalline. Minor dolomitic layers are found intercalated with the predominantly calcitic marble in this area, while major units of dolomitic marble show a spatial association with metavolcanic rocks (Lumbers, 1982, p.19). Some of these units are quarried for building stone and the production of magnesium (Figure 2.2, NO–27).

Chemical analyses of marble in the Renfrew area are reproduced in: Industrial Minerals of the Pembroke–Renfrew Area, Part 1: Marble (Storey and Vos, 1981).

## COE HILL

Coe Hill designates an area from Bancroft to Madoc, and Apsley to Weslemkoon. Marbles in this area are generally medium to fine crystalline, corresponding to an intermediate to low grade metamorphism (Lumbers, 1964, p.7).

Part of this area was mapped in detail by Bartlett and Moore (1985) who make, where possible, the following distinctions in carbonate metasediments: dolomitic marble, calcitic marble, interlayered calcitic/dolomitic marble, dolomitic marble with abundant lenses and layers of chert, tremolite marble and skarn. As a group these map units are distinguished from interlayered carbonate and siliceous metasediments.

### MADOC TOWNSHIP

In his report on the geology of Madoc Township, Hastings County, Hewitt (1968, p.11, 12) characterizes marble of the northern part, occurring in the Queensborough syncline, as blue grey and well bedded. Elsewhere, white, buff, green, black and pink marble are common. Several quarries are operated for the production of terrazzo chips in the area (Figure 2.2, NO–25) which are detailed in the Tweed District descriptions.

### MARMORA TOWNSHIP

Resources in Marmora Township, Hastings County, are largely part of the Marmora Formation (Bartlett *et al.*, 1984, p.15), a predominantly carbonaceous metasediment in Cycle III of the Belmont Lake volcanic complex. Up to 2,000 m thick, this formation can be distinguished into a lower, predominantly dolomitic part (algal mats), and an upper non–stromatolitic calcitic part.

### BARRIE, CLARENDON AND PALMERSTON TOWNSHIPS

Fine crystalline pink and white dolomitic marble extends across Lots 27, 28 and 29, Concessions 9 and 10, Barrie Township, Frontenac County (Hewitt, 1964, p.56). The presence of tremolite in the marble detracts somewhat from its potential as a building stone, although it may still have potential for terrazzo.

Marbles of the Clarendon Lake area, Clarendon Township, are distinguished into dolomitic and calcitic dominated varieties (Moore and Morton, 1980, p.26). They consist of massive or layered white, grey, bluish grey, greyish buff and buff, fine to coarse crystalline carbonates with occasional intercalation of metavolcanic or metasedimentary beds.

Verschuren et al. (1985, p.52) mention two areas in Lot 37– 39, Con. 2, Clarendon Township, Frontenac County, which have potential for marble development. Verschuren et al. (1985, p.85) also mention an area in Lot 10, Con. 11, Palmerston Township, Frontenac County, with a similar potential for development.

In the literature, Clarendon and Palmerston Townships are mentioned in connection with a wide band of dolomitic marble (Hewitt, 1964, p.58) between Ompah and Plevna. This marble was tested for building stone purposes as early as 1935 (Goudge, 1938, p.74).

## CARLETON PLACE

The area surrounding the Town of Carleton Place is characterized by medium to high grade metamorphism of the underlying rocks. In a study of the Lavant area Pauk (1984, p.7, 8) correlates older metasediments and metavolcanics with the Herman and Mayo Groups in the Bancroft area, and some younger formations, caught up in structural zones in the northwest part, with the Flinton Group. Carbonate metasediments are generally medium to coarse crystalline, occasionally fine crystalline, calcitic and dolomitic marbles that occur as thick beds or as thinner beds intercalated with clastic metasediments or metavolcanics (Pauk, 1984, p.35).

In the Lavant area massive units of white, medium to coarse crystalline, calcitic marble, with occasional colour variations to grey–blue or salmon pink, are the most widely distributed variety of a total of 8 subunits. These subunits are distinguished primarily on the basis of mineral content (Pauk, 1984, p.35).

### DARLING TOWNSHIP

A major operation for the production of calcite chips, filler and whiting is conducted by Steep Rock Calcite in Darling Township, Lanark County. The property includes two building stone quarries in the Tatlock area previously held by Angelstone Limited (Guthrie Farm) and Omega Marble Tile and Terrazzo Limited (Lot 6, Con. 5, S.W. half), respectively (Hewitt, 1964, p.61, 64). A white medium-crystalline calcitic marble is reported by Hewitt (1964, p.62).

A wide belt of low silica content (<3% silica) marble is bounded by dolomitic marble to the west and by zones with higher silica content (3% to 11%) to the east. The latter zones underlie the initial quarry, which produced crushed marble of high brightness but of limited use as a calcite filler.

The low silica zone marble reaches true thicknesses of 85 m. Here the marble is white, medium to coarse crystalline, with negligible phlogopite and essentially free of graphite.

The footwall boundary is determined by impure dolomitic marble with increased silica content and inclusions of boudinaged amphibolite. Rare boudinaged quartz veins cross cut the marble belt.

Along strike, the ore body is also limited by higher silica content. Quartz and tremolite are the major silicate minerals. The presence of phlogopite and diopside (Hewitt, 1964, p.66) has been recorded.

### LANARK AND RAMSAY TOWNSHIPS

Banded, white and grey, calcitic marble trends northeasterly through Lanark Village, in Lot 1, Con. 1, Lanark Township, Lanark County (Hewitt, 1964, p.60). Building stone, lime and road metal were produced locally (Storey and Vos, 1981, p.62).

Northeasterly trending calcite marble, layered with graphite, silicate minerals and dolomite crystals, and interlayered with paragneiss units, is reported in Lots 26 and 27, Con. 5-9 of the same township (Storey and Vos, 1981, p.95). Additional analyses are given by Grant and Kingston (1984, p.201- 204).

White calcitic marble is reported in Lot 8, Con. 6, Ramsay Township, Lanark County, by Hewitt (1964, p.17). Grant and Kingston (1984, p.211-212) record coarse to medium crystalline marble with minor graphite, phlogopite and muscovite in this area.

### SOUTH SHERBROOKE TOWNSHIP

White, calcitic marble, occasionally white and grey laminated with phlogopite and graphite, occurs in Lot 13, Con. 2, South Sherbrooke Township, Lanark County (Grant and Kingston, 1984, p.192).

Predominantly fine crystalline dolomitic calcite marble, grey or light and dark grey laminated, with occasional pods or blocks of white, plagioclase-rich silicate rocks, occurs in Lots 16, 18, 19, Con. 10 and 11, South Sherbrooke Township (Grant and Kingston, 1984, p.214-216).

## KALADAR

In the Kaladar area, marble quarries are located in Lot 7, Con. 1 and Lots 2 and 3, Con. 6, Elzevir Township, Hastings County (Hewitt, 1964, p.52), as well as in Lot 11, Con. 14, Hungerford Township, Hastings County (Figure 2.2, NO-26).

## WESTPORT

Favourable mention is made by Grant and Kingston (1984) of marble outcrops in the following townships in the Westport area.

### OLDEN TOWNSHIP

White, massive, medium to coarse crystalline calcite marble occurs within the Mountain Grove Intrusion in Lot 2, Con. 5, Olden Township, Frontenac County, in an area 150 to 200 m wide and 650 m long on the site of the former Long Lake Zinc Mine. This is potentially of interest as industrial filler material (Grant and Kingston, 1984, p.133-135), although a larger body would be more desirable for economic operation.

White to light grey, fine to medium crystalline calcitic marble with only minor graphite and phlogopite occurs in Lot 6, Con. 3 (Grant and Kingston, 1984, p.127-130).

### UNITED COUNTIES OF LEEDS AND GRENVILLE

White calcitic, coarse-grained marble in Lot 14, Con. 7, Rear of Leeds and Lansdowne Township, United Counties of Leeds and Grenville, is of potential interest as filler material (Grant and Kingston, 1984, p.159-161). Predominantly white calcite marble, with grey bands and minor graphite and pyrite, outcrops in Lot 21, Con. 9, South Crosby Township, United Counties of Leeds and Grenville (Grant and Kingston, 1984, p.170).

### STORRINGTON TOWNSHIP

White calcitic marble with minor phlogopite and graphite and some pyrite and muscovite occurs in Lot 10, Con. 13, Storrington Township, Hastings County (Grant and Kingston, 1984, p.170-172).

# Calcite Veins

Substantial amounts of calcium carbonate have been encountered in calcite veins. In the Thunder Bay area they are associated almost exclusively with shales and wackes of the Rove Formation and ironstone of the Gunflint Formation. Here they occur as simple and composite veins in faults and fissures structurally related to diabase dykes and sills (Speed et al., 1985, p.10). The veins were described as follows by Speed et al. (1985, p.11):

> "The veins commonly consist of a gangue of calcite and/or barite with minor quartz and fluorite. Metallic minerals found in these vein systems are argentite, native silver, galena, sphalerite, chalcopyrite and pyrite. The majority of these veins were mined for their silver, lead, zinc or copper content in the late 1800s and early 1900s."

Vein deposits of potential economic importance as a source of calcium carbonate include the Gaherty Island and Kawashegamuk Lake deposits in the Kenora area, the Gravel River, Neepatyre Mine, South McKellar Island and Spar Island deposits in the Thunder Bay district and the Parkin Township deposit, northeast of Sudbury.

Elsewhere in Ontario, calcite veins of a purity and size to be of interest as sources of filler-grade calcium carbonate are scarce. A particular example occurs in Frontenac County in southeastern Ontario, as described below.

In 1946, a large vein of massive, cream-coloured to slightly pink calcite was worked by Marlhill Mines Limited in Palmerston Township. The vein cuts a granite and varies in width from 18 m to 30 m, with an east-west strike and a near vertical dip. It has been traced by drilling over a length of more than 200 m and to a depth of 45 m and, except for rare wallrock fragments, consists totally of calcite.

### GAHERTY ISLAND DEPOSIT

The Gaherty Island deposit (Figure 2.1, NO-3), 16 km south of and accessible by boat from Kenora, consists of a dolomitic carbonate vein with minor amounts of quartz and sulphide minerals in a pyroclastic host rock (Storey, 1986, p.79). The vertical vein is at least 6 m wide. The dolomite content weathers rusty brown and appears to be predominantly ankerite (Storey, 1986).

### KAWASHEGAMUK LAKE DEPOSIT

Carbonate veins occur in the area of Kawashegamuk Lake, 27 km southeast of Dinorwic (Figure 2.1, NO-4) (Storey, 1986, p.83-85). The area can be reached by forest access road exiting south from Highway 17 at 10.7 km southeast of Dinorwic. Chemical analyses indicate that the carbonate is an iron-rich dolomite.

### GRAVEL RIVER CALCITE OCCURRENCE

Calcite veins in Archean hornblende-biotite granite are found in a high cliff on the western shore of the Gravel River, north of Rossport (Figure 2.3, NO-14) (Speed et al., 1985, p.72-75). A timber access road leads north from Highway 17 at a point 52 km east of Nipigon. After 15 km this road passes close by the occurrence after having crossed the Gravel River itself. Samples taken from the veins, the largest of which is 4 to 5 m wide, show the carbonate to be very pure calcium carbonate with only minor amounts of silica.

### NEEPATYRE MINE

The Neepatyre Mine is located on the widest part of an east-trending vein cutting across Paipoonge and Neebing Townships, 10 km west of Thunder Bay (Figure 2.1, NO-10). The near vertical vein cuts flat-lying cherty taconite iron formation of the Gunflint Formation (Speed et al., 1985, p.97).

The Neepatyre Mine consists of 2 open cuts, respectively 9 m and 6 m wide, in Neebing Township. Coarse crystalline calcite from these cuts was crushed and screened for production of stucco dash, chicken grit and landplaster. Up to July 1927 one hundred and fifty tons of material had been marketed (Speed et al., 1985, p.99). The mineralization in this vein is described by Speed et al. (1985) as follows:

> "The main constituent of the Neepatyre vein is massive white calcite. A transparent variety of calcite (Iceland Spar) is also said to occur. This form of calcite was not observed during the visit to the property. Quartz occurs as either the white or amethystine variety. Barite and fluorite also occur sporadically throughout the vein. Metallic minerals are rare and sparsely disseminated in the vein material and include galena, sphalerite, chalcopyrite and pyrite."

### SOUTH MCKELLAR ISLAND DEPOSIT

The South McKellar Island deposit, 22 km southeast of Thunder Bay on South McKellar Island (Figure 2.1, NO-13), is only accessible by boat. The island is the most northeasterly of a chain of islands including Jarvis, Spar and Thompson Islands, all of which are underlain by a diabase dike striking in this direction and extending from the mainland at McKellar Point. A vertical, composite barite-calcite vein with minor fluorite, sphalerite, galena, pyrite and silver, strikes due northwest across the island (Speed et al., 1985, p.142). The 150 m exposed length of the vein is from 13 to 20 m wide and is the largest known composite vein in the region (Speed et al., 1985, p.142). Sections of this vein are either predominantly barite or calcite and as such the vein is a major source of good quality barite and calcite in the region (Speed et al., 1985). Mining of this vein has taken place since discovery by the McKellar brothers in 1869; shipments of barite were made in 1894 and further drilling took place in 1967.

## SPAR ISLAND OCCURRENCE

Spar Island is one of the islands underlain by a northeast striking diabase dike leaving the mainland at McKellar Point. It is approximately 35 km due south of Thunder Bay (Figure 2.1, NO–12). Calcite occurs in a near–vertical composite vein striking 160 degrees across the southern part of the island. Vein walls and a central rib of barite alternate with massive calcite bands in which some quartz and barite occur. A large horse of diabase in parallel attitude is enclosed in the 5 m wide south shore outcrop (Guillet, 1963, p.12). The proportion of major minerals is approximately: calcite – 65 percent; barite – 25 percent; and quartz – 10 percent (Guillet, 1963, p.12).

The history of the mining operations of this deposit since 1846 is described by Speed et al. (1985, p.148, 149). Production figures are not available.

## PARKIN TOWNSHIP DEPOSIT

A body of massive calcite, here classified as a vein deposit, is found in Parkin Township, 40 km north–northeast of Sudbury (Figure 2.3, NO–19). Drilling has shown that this body has limited depth extension.

The calcite deposit is located in Lot 8, Con. 3, Parkin Township, in an area of brecciated quartzites and diabase, which includes some fragments of the carbonate–rich Espanola Formation. The area is characterized by faults and fractures which Karvinen (1982) relates to a local rift structure which had been active from early Proterozoic to post–Nipissing time. The hydrothermal alteration and brecciation is apparently related in time to the intrusion of Nipissing diabase. It is conceivable that carbonates originating in the Espanola Formation were remobilized and concentrated in the present lens–like body as suggested by W. Meyer (Resident Geologist, Ministry of Northern Development and Mines, Sudbury – see Vos, 1986).

The calcite deposit can be subdivided into three grades according to drill results by Raretech Minerals Inc. (Constable, 1986). These grades are provisionally classified as good, fair and poor calcite (Table 2.1).

Whereas good–grade calcite has assayed 99.2 percent $CaCO_3$ in surface showings, the contents of MgO, $SiO_2$ and $Fe_2O_3$ increase towards the contact with the fair grade calcite.

On the basis of a total of 8 drill holes combining 1458.5 feet (444.5 m) of BQ drill core, a possible tonnage of 23,370 tonnes good grade calcite, 58,015 tonnes fair grade calcite and 52,390 tonnes fair to poor grade calcite was established by Constable (1986). Sulphide stringers and disseminated pyrite in siliceous units with low values in nickel, copper, zinc and gold also occur within the deposit (Constable, 1986).

**Table 2.1. CHEMICAL ANALYSES OF PARKIN TOWNSHIP CALCITE**

| Grade: | Good | Good to Fair | Fair |
|---|---|---|---|
| $SiO_2$ | 0.93 | 2.47 | 9.94 |
| $Al_2O_3$ | 0.02 | <0.01 | 0.06 |
| CaO | 55.6 | 54.5 | 27.1 |
| MgO | 0.26 | 0.55 | 17.6 |
| $Na_2O$ | 0.03 | 0.02 | <0.01 |
| $K_2O$ | 0.01 | 0.01 | 0.01 |
| $Fe_2O_3$ | 0.11 | 0.14 | 3.62 |
| MnO | 0.07 | 0.08 | 0.22 |
| $TiO_2$ | <0.01 | 0.01 | 0.01 |
| $P_2O_5$ | 0.01 | 0.01 | 0.01 |
| LOI | 43.2 | 42.5 | 41.8 |
| TOTAL | 100.2 | 100.3 | 100.4 |

*Analyses by X-Ray Assay Laboratories Limited, Don Mills, Ontario (Constable, 1986)*

# Carbonatites

The term carbonatite applies to carbonaceous material in igneous rock complexes. In surface outcrop the complexes are characterized by concentric distribution of a great variety of rock types.

In carbonatite complexes there is frequently a gradational transition between rock types, and not all of the types are necessarily represented in each complex. A typical distribution sequence is an outer ring of altered or fenitized country rock followed by syenitic rock low in quartz, calcium and ferromagnesian minerals (Heinrich, 1966, p.323). Towards the centre, ferromagnesian-rich ultramafic rocks in rings, dykes or bodies may be encountered, accompanied by concentrations of magnetite, ilmenite and/or other metallic minerals. Either pure carbonate or calc–silicate rock occupies the core of the complex.

In many instances the elements lacking from the outer rings of a carbonatite complex are compensated for at the centre, the chemical balance indicating a transport of elements from the outskirts toward the centre of the complex. Whether this chemical distribution was obtained magmatically or by metasomatic transfer of elements, possibly with the help of groundwater circulation as suggested previously (Vos, 1980), remains to be established for each deposit individually. Such knowledge is essential for a comprehensive evaluation of mineral potential. For purposes of resource evaluation it is necessary only to establish the quantity and chemical composition of carbonaceous material available in the complex. In areas of granitic terrain in the Canadian Shield the carbonatite complexes are frequently the only geological environment in which economic concentrations of calcium carbonate are found. As such they are an important complement to the limestone resources of Ontario.

## ONTARIO DEPOSITS

The distribution of carbonatite–alkalic complexes in Ontario is shown by Satterly (1968; Map P.452). Some of these complexes have been examined much more closely than others and whether or not calcium carbonate is present is not known with certainty in some instances.

Four of the better known complexes with a carbonate content of potential economic interest are discussed below. They are the Firesand River and Prairie Lake complexes in the Wawa and Marathon areas, northeast and north of Lake Superior, the Cargill Complex southwest of Kapuskasing, and the Spanish River Carbonatite Complex west of Sudbury.

### FIRESAND RIVER COMPLEX

The Firesand River Complex, approximately 7 km east of Wawa (Figure 2.3, NO–17), covers approximately 4.5 km$^2$ (Sage, 1983a; OFR 5403, p.2) that is underlain by a core of ferruginous dolomite and a calcitic rim which consists of "a complex mixture of carbonate, silicocarbonatite, ijolite and wall rock fragments ..." (Sage, 1983a, p.8).

Fenitization has affected the Early Precambrian supracrustal host rocks adjacent to the complex (Sage, 1983a, p.13–16). In a quartz–feldspar porphyry Sage notes a loss of silica and sodic metasomatism of the feldspars. The calcite carbonatite of the calcitic rim occurs in a ring, or a succession of rings, up to a total width of 600 m (Parsons, 1961, p.26). The potential of these rocks as a source of lime was tested by the Algoma Steel Corporation Ltd. in 1970 with surface work and drilling totalling 717 m in eight holes. The contents of phosphorous, silica and magnesium apparently proved too high for use of this material as a source of lime in the sinter plant at Wawa.

### PRAIRIE LAKE COMPLEX

The Prairie Lake Complex is a circular carbonatite approximately 3 km$^2$ in an area located northwest of Marathon, about 25 km north of Lake Superior (Figure 2.3, NO–15).

The complex consists of an intricately interfingered sequence of arcuate to curvolinear bands of carbonate rock and ijolite, the ijolitic rocks being more abundant towards the core. While calcite is the dominant carbonate phase in the complex, dolomite commonly occurs as accessory grains in carbonate units or ijolitic rocks (Sage, 1983b, p.26–31).

The possibility of using Prairie Lake calcium carbonatite for production of cement has been considered by Nuinsco Resources Limited, the company presently holding options on the deposits. Consistent with production of cement and lime from carbonatites in Sweden (Alno Complex), Uganda (Tororo Complex) and Brazil (Jacuparanga Complex) both the Firesand River and Prairie Lake Complex provide an exploration target for cement stone north of Lake Superior.

### CARGILL COMPLEX

A readily accessible carbonatite intrusion is located 32 km southwest of Kapuskasing in Cargill Township (Figure 2.3, NO–16). The intrusion took place approximately 1.74 billion years ago (Gittins et al., 1967) in an environment of hybrid quartz diorite gneiss and amphibolite of Archean age (Bennett et al., 1967). Major rock types of the complex are carbonatite and pyroxenite (Sandvik and Erdosh, 1977). The surface magnetic expression of the intrusion indicates three centres, identified respectively with the South and North Subcomplexes and a poorly defined West Subcomplex, 4 km west of the main intrusive.

In the South Subcomplex a total area of approximately 1 km$^2$ consists of an outer ring of calcite carbonatite and a core of dolomite carbonatite. Siderite carbonatite is indicated as well, but very little of this material has actually shown up in subsequent drilling (Ford, 1986, p.326). The calcite carbonatite is near the surface or exposed in contact with the pyroxenite envelope in some areas.

In his report on the Cargill Complex, Sage (1983c, p.23–26) reports 45 major element analyses of sovite of which 18 have a CaO content of 45% or more. The balance in these analyses is made up of $SiO_2$ (average: 2.66%), $Al_2O_3$ (average: 0.57%), $Fe_2O_3$ (average: 0.95%), FeO (average: 2.37%), MgO (average: 3.39%), $Na_2O$ (average: 0.47%), $K_2O$ (average: 0.22%), $TiO_2$ (average: 0.14%), $P_2O_5$ (average: 3.93%), S (average: 0.34%), MnO (average: 0.11%), $CO_2$ (average: 3.36%) and water (average: 0.38%). Some beneficiation or selective mining would be necessary to obtain a suitable cement source rock from this deposit, though calcium carbonate could be produced as a by–product if the phosphates present were to be mined.

## SPANISH RIVER COMPLEX

The Spanish River Carbonatite Complex is approximately 55 km northwest of Sudbury, on the boundary of Venturi and Tofflemire Townships (Figure 2.3, NO–18). The complex has a total surface area of approximately 2 km$^2$, but bedrock is exposed in only two areas where extensive bulldozing has been completed (Sage, 1983d, p.4). The rock types of the complex, occurring within a halo of fenitized granitic rock, include silicocarbonatite, ijolite and pyroxenite in the periphery, and purer carbonatites towards the core. The latter 5 samples have more than 45% CaO (Sage, 1983d, appendix). Not enough information is available to evaluate the potential of this complex as a source of calcium carbonate due to poor exposure and limited drilling. It is identified here primarily because of its geographic location near an area of industrial and agricultural markets.

# Marl

Marl is essentially a soft limestone mud that accumulates in the beds of certain spring–fed landlocked lakes and marshes. It results from biochemical precipitation induced by photosynthesis of algae. Where the lake waters are nearly saturated with calcium carbonate, as a result of the abundance of nearby limy tills or bedrocks, these algae are so prolific as to give a most distinctive and attractive blue–green colour to the water.

Marl lakes are particularly abundant in southern Ontario, but a few deposits are also known in the Timmins area and the Nipigon and Thunder Bay areas. More than a hundred occurrences have been described (Guillet, 1969).

From 1889 to 1919 marl was extensively used in Ontario for making portland cement. For much of this period it was used exclusively, with clay, in fourteen plants throughout southern Ontario, but by 1919 all had either closed or converted to limestone. For cement, as for most limestone markets, marl proved inferior because of its high water content and greater variability, the latter due in part to the dredging method of excavation.

In recent years, marl has received more interest in northern Ontario, in spite of the fact that deposits are scarcer than in the south and their quality is generally only fair. This interest stems largely from the scarcity of limestone in the predominantly Precambrian terrains. Deposits near Timmins, Thunder Bay (Figure 2.1, NO–10) and Sioux Lookout (Figure 2.1, NO–5) have each been considered for portland cement manufacture and agricultural soil conditioner, neither of which require particularly high purity.

Finely–divided organic matter and clay are the principal impurities in marl, and Ontario deposits vary considerably in these regards. The purer deposits are moderately white in colour, and several attempts have been made to develop them for filler applications. However, their high natural moisture content (50 to 75 percent) and their extreme fineness (70 to 90 percent finer than 325 mesh) has made their handling and processing both difficult and costly. The best products have had whiteness ratings of only about 80 (on a standard scale of 1 to 100), while whiteness ratings from the best marble deposits are 95–96.

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# Part 3 — Properties, Specifications and Uses of Limestone Commodities

# Limestone Aggregates

Limestone aggregates (crushed limestone) represent the single largest category of limestone production. Most of the production is associated with the requirements of the construction industry as either road building material or as concrete aggregate. Other major uses include rubble and riprap, railroad ballast and stone for a wide variety of other uses.

Ontario is blessed with an abundance of limestone resources. However, regional differences in the supply and economic accessibility of the resource do result in significant differences in the supply and demand patterns for stone. As a consequence, the industry shows a degree of dynamism unusual for a low priced commodity.

## SOURCES

As documented in other parts of this report the limestone resources of Ontario are extensive and deposits are found in most regions of the province. The industry, however, is concentrated in southern Ontario, especially along the Niagara Escarpment, and in eastern Ontario. The major producing centres include Halton, Ottawa–Carleton, Simcoe, Niagara, Hamilton–Wentworth, Northumberland, Essex and Oxford. Together, all these areas accounted for 71% of all stone production for all uses.

Centres of major urban growth such as Metropolitan Toronto, Peel Region, York Region and Durham Region lack accessible deposits of limestone for use as aggregate material. However, crushed gravel is readily available in these regions and is usually an acceptable substitute for crushed limestone. Transportation costs play a significant role in determining the relative use of crushed limestone and gravel in construction applications in these regions. As a rule of thumb, the area west of Highway 11 (Yonge St.) relies on crushed limestone from quarries on the Niagara Escarpment to meet its aggregate requirements. Conversely, the area east of Highway 11 relies on crushed gravel for much of its aggregate requirements. Similarly, the southwestern Ontario counties of Lambton, Huron, Middlesex, Kent, Essex and Elgin rely on imports of crushed stone from other regions of Ontario or from the United States to meet their aggregate requirements. These aspects of regional supply/demand and transportation costs will be more fully explored in a later section of this report.

## PRODUCTION TECHNOLOGY

The production methods for crushed limestone have not changed significantly in their basic principles in many years. Technological change has been mainly associated with increases in the size of equipment for drilling, blasting, hauling and crushing rather than the actual methods of quarrying.

In Ontario, production of crushed limestone is exclusively by open quarry; there is no underground mining of limestone. Quarries vary considerably in size; number, depth and width of benches; and type of processing equipment. The principal factors affecting quarry size and scope of operations are the quality of the deposit (depth, width, bedding integrity, and physico–chemical uniformity of the deposit), available markets (number of product sizes and market volumes for each size), and the financial capability of the operator.

There is no standard design for aggregate plants. Each deposit and each range of desired products requires careful analysis and a specific design engineered for the location. By selecting various available standard components and assembling them in combinations that provide the required crushing, sizing, washing, benefication, stockpiling and loading, a wide variety of needs and problems can be efficiently handled. Some of the components can be purchased as portable units, thus permitting ready relocation after the depletion of a source or the satisfaction of a short–term need such as a highway project.

The optimum size of a plant depends on the demand for the desired quantities of product. Currently in Ontario crushed stone operations can be found with annual production volumes ranging from about 50,000 tonnes to 9 million tonnes. Due to the heavy investment required for a large fixed plant it is necessary to carefully evaluate production capacity in relation to the size of the deposit available for processing and the market. A minimum of a 20–year supply of extractable material is generally required before a large fixed plant can be justified.

As mentioned previously, the major technological factors affecting the crushed stone industry have to do with the increasing size of both mobile and fixed production equipment. Plants with through–puts in excess of 1,500 tonnes per hour are now common, whereas 30 years ago a large plant would have an effective capacity of approximately 400 tonnes per hour.

Equipment has increased dramatically in size. Haulage trucks have changed from 12 to 15 tonne capacity to 50 to 75 tonnes. The shift to larger haulage trucks has been parallelled by a shift to larger extraction equipment, as equipment manufacturers and users seek to optimize overall production efficiencies and thereby reduce the unit costs of production. Smaller crawler shovels of 0.75 to 3 cu. m capacity have been replaced by units of up to 6 cu. m, or by rubber–tired front–end loaders of 7.5 to 9 cu. m or even up to 18 cu. m capacity.

A similar tranformation has occurred in terms of the size of the operators. Large equipment is very expensive and can only be purchased by large organizations. There has been a significant trend to consolidation in the industry in terms of the integration of smaller producers into a larger organization and the development of major vertically integrated operations such as those of the cement producers. The cement producers, in particular, have significantly extended their interests in aggregate production in recent years. This expansion has been brought about to satisfy the internal demand of the cement producers for concrete aggregate, as well as a strategic decision on their part to diversify operations. While there will always be a role for the smaller operator serving local markets, the trend is certainly to larger plants financed by large corporations.

Because the demand for aggregates in Ontario is highly seasonal, and because of the difficulties and expense of operating in the winter months, most quarries operate less than 12 months. Larger operators are able to satisfy winter demand from stockpiles. All operators take advantage of the winter slowdown to conduct necessary maintenance on key items of plant and equipment and in many cases perform progressive rehabilitation of extracted areas.

Figure 3.1 depicts a flow diagram for a typical large, modern crushed limestone processing plant. The basic production processes and features of some of the equipment associated with such plants are detailed below.

## DRILLING AND BLASTING

Drilling and blasting operations represent the first major phase of crushed stone production after the removal of the overburden. Drilling is generally conducted using rotary percussion drills, although churn drills and down–the–hole drills may also be used. Typically, holes are 7 to 15 cm in diameter. Hole spacing is dependent on the fracturing properties of the rock and the desired bench width, but is typically conducted on patterns of 1.8 m x 1.8 m, 1.8 m x 3.0 m, 2.4 m x 3.0 m or 3.7 m x 3.7 m. Holes are generally drilled to bench height.

Modern blasting techniques rely almost exclusively on AN/FO (ammonium nitrate–fuel oil) as the explosive. Dynamite and other such explosives are rarely used. The AN/FO may be mixed in the hole but is typically mixed in a batching plant on site and transported to the drill site in special trucks. There is a wide variation in the make–up of the mixture due to variations in the integrity of the rock and the desired shattering pattern. It is normal for full bench faces to be blasted in a single shot, and this generally implies one or two shots per week. Many operators rely on contract drillers and blasters, having found such arrangements to be less expensive than employing their own staff in what may be only a part–time operation.

Secondary breaking of rock, if required, is generally conducted by either impact hammer or drop ball. The choice depends on the amount of secondary breaking required and the difficulty of breaking. On occasion secondary blasting may be used for particularly large and/or highly competent blocks. Very large pieces of stone may be reserved for sale as armour stone for shoreline protection or sold to dimension stone producers if the material is of suitable quality.

## PRIMARY CRUSHING

Proper sizing of the primary crusher to match the capacity of the bucket or loader is essential for high productivity. The crusher should be able to accommodate the largest–sized stone that the bucket can efficiently handle. This minimizes the chance of oversized rock jamming the crusher and obstructing the flow of material.

The selection of the primary crusher is influenced by the required capacity, the range of stone sizes to be produced and the compressive strength of the rock. Jaw crushers are the oldest type of primary crusher. They may be of the double toggle or dual jaw type, the single toggle or overhead eccentric type, or have two movable jaws. Jaw crushers are generally more compact than gyratory crushers and can be set with wider discharge ends than gyratory crushers. However, for the same size unit the gyratory has over twice the capacity of the jaw crusher. Gyratory crushers are also available in much larger sizes than jaw crushers. Jaw crushers range in capacity up to approximately 600 tonne/hr. and in size from 61 cm x 91 cm to 168 cm x 213 cm and can crush stone down to 7.5 cm to 13 cm. The jaw crusher is typically less expensive to operate than the gyratory for lower capacities.

Gyratory crushers consist of a conical head inside an outer concave bowl, a slow gyratory or eccentric movement of the head compressing the stone against the fixed crushing surface. Gyratory crushers are available with capacities in excess of 300 tonnes per hour and sizes up to 183 cm or larger. The smallest discharge openings range between 9 cm and 23 cm. For equal capacity, the gyratory weighs less and costs less than the jaw crusher, but requires more space, has more restricted discharge openings and generally high maintenance costs. However, it is the unit of choice when high through–put is required.

Impact crushers may also be used. The impact crusher consists of one or two impeller breakers that rotate at speeds of 250 – 1000 rpm. Rock size reduction is caused by the stone hitting the sides of the breaker, other pieces of stone and steel breaker bars inside the crusher chamber. The breaker bars can be adjusted to allow for the production of stone down to 4 cm to 5 cm, thus perhaps eliminating the need for secondary crushing. The crusher tends to produce a cubic–shaped product. Capacities range from 200 to 2,000 tonnes per hour.

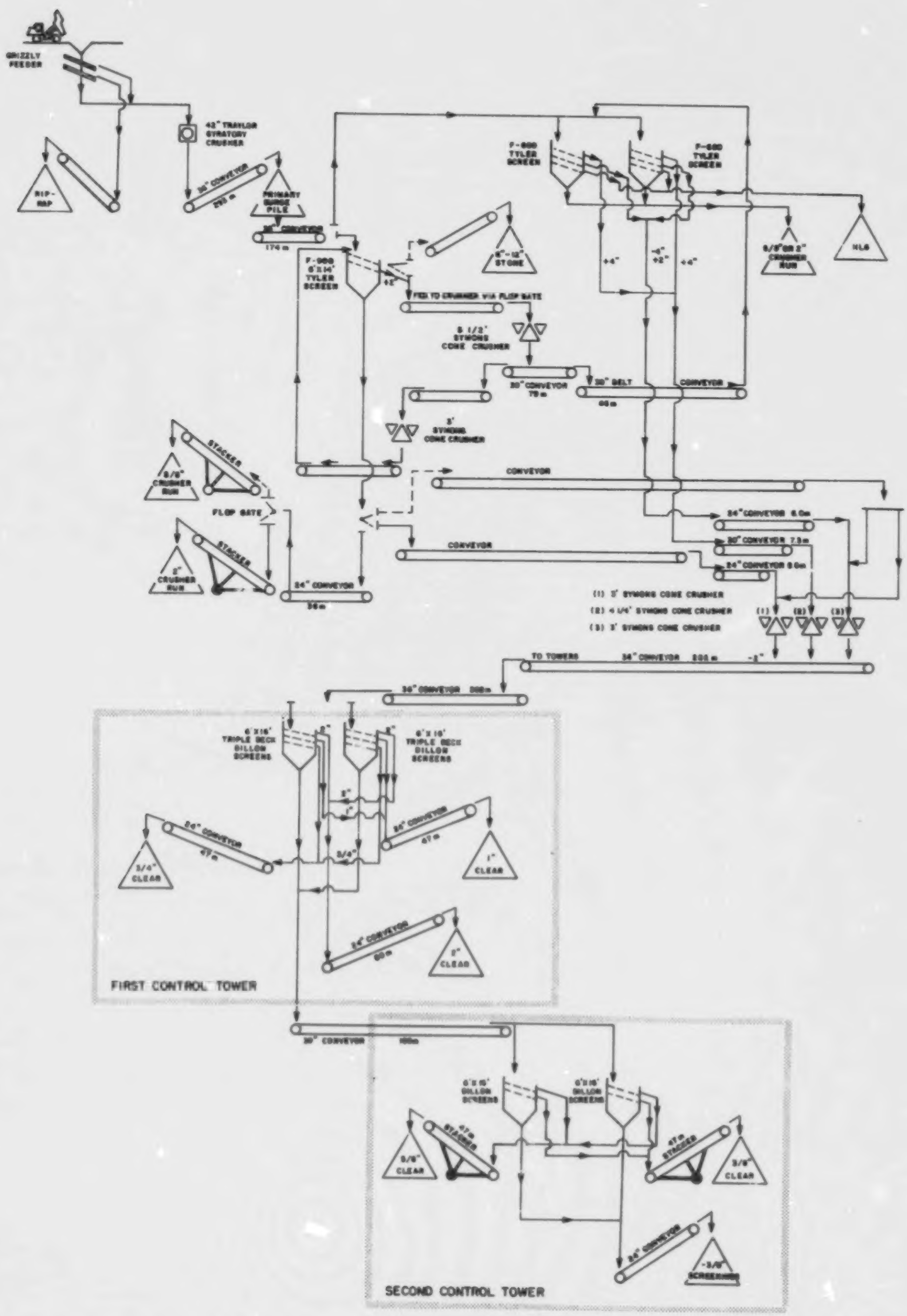

GRIZZLY FEEDER
RIP-RAP
42" TRAYLOR GYRATORY CRUSHER
36" CONVEYOR
293 m
PRIMARY SURGE PILE
36" CONVEYOR
174 m
F-900 6' X 14' TYLER SCREEN
+2"
4"-12" STONE
FED TO CRUSHER VIA FLOP GATE
5 1/2' SYMONS CONE CRUSHER
30" CONVEYOR
79 m
30" BELT
CONVEYOR
46 m
3' SYMONS CONE CRUSHER
F-800 TYLER SCREEN
F-800 TYLER SCREEN
+4"
-4" +2"
+4"
5/8" OR 2" CRUSHER RUN
HL6
STACKER
5/8" CRUSHER RUN
FLOP GATE
STACKER
2" CRUSHER RUN
24" CONVEYOR
36 m
CONVEYOR
CONVEYOR
24" CONVEYOR 6.0m
30" CONVEYOR 7.3m
24" CONVEYOR 9.0m
(1) 3' SYMONS CONE CRUSHER
(2) 4 1/4' SYMONS CONE CRUSHER
(3) 3' SYMONS CONE CRUSHER
(1)
(2)
(3)
TO TOWERS
36" CONVEYOR 200 m
-1"
36" CONVEYOR 300m
6' X 16' TRIPLE DECK DILLON SCREENS
6' X 16' TRIPLE DECK DILLON SCREENS
2"
2"
2"
1"
3/4"
24" CONVEYOR
47 m
3/4" CLEAR
24" CONVEYOR
47 m
1" CLEAR
24" CONVEYOR
60 m
2" CLEAR
FIRST CONTROL TOWER
30" CONVEYOR
100m
6' X 16' DILLON SCREENS
6' X 16' DILLON SCREENS
47 m STACKER
5/8" CLEAR
47 m STACKER
3/8" CLEAR
24" CONVEYOR
-3/8" SCREENINGS
SECOND CONTROL TOWER

Figure 3.1. FLOW DIAGRAM OF TYPICAL LARGE, MODERN CRUSHED-LIMESTONE PLANT, FEATURING FLEXIBILITY IN SIZES AND GRADATIONS.

]

### SECONDARY CRUSHING

Secondary crushing is employed to reduce material to more salable size distributions. There are a variety of secondary crushers on the market, most of which are smaller, lower capacity, higher speed variations of primary crushers. The most common secondary crushers are hammermills and cone crushers, a type of gyratory crusher. Cone crushers are available which can crush stone to 100% passing 10 mesh at rates up to 1,000 tonnes per hour.

Pulverized stone is processed in either wet or dry grinding circuits using hammer mills, cage mills, roller mills and ball, tube, rod and pebble mills. The choice of mill depends on the type of stone being processed, the degree of fineness desired, and the particle size distribution desired. Details of these mills are to be found in the section on Fillers and Extenders.

### CONVEYING AND SCREENING

After crushing, the stone is generally conveyed by belt conveyor to a series of single, double and triple–deck screens which are used to separate products by size range. Vibrating screens are generally employed to prevent clogging. Screen materials vary from punched metal plates to woven wire, rubber or urethane. Urethane screens are enjoying increased use because of their resistance to wear, and their lower tendency to clog with fine particles. Screened product may be conveyed to surge piles for subsequent reclaiming and stockpiling or sale, or to a wash plant.

### WASHING

Some quarries have wash plants to remove residual clay, shale, silt and stone dust from the crushed stone. The prevalence of washing has increased in recent years as customers increase their quality requirements for stone. Wash plants may incorporate scrubbing systems, water jets or sprays, or log washers, depending on the degree of washing required and the type of material to be removed. Very elaborate washing systems employing flotation processes are common in Europe. Washed stone is generally dried in rotary driers, a necessary step for some markets such as asphalt aggregate which require bone–dry stone.

### STORAGE

Screened and/or washed stone is generally stored in uncovered stockpiles on the ground. Reclaim may be either by underground conveyor, sometimes with product mixing capabilities, or by front–end loader. In some cases the reclaimed product is moved to storage bins which empty directly into waiting trucks or rail cars. Plants may maintain a diverse range of product sizes; typically about 10 size gradations.

### ENVIRONMENTAL CONTROL

The crushing, screening and conveying of stone necessarily creates significant amounts of dust. Techniques to reduce dust levels include the use of covered conveyors, water sprays and special surfactant compounds. Road dust is generally controlled by the use of water trucks and the application of calcium chloride solutions.

Waste wash water is generally discharged to settling ponds for subsequent re–use. Make–up water may be derived from special wells or from the surface run–off of the quarry.

In urban and semi–urban areas noise control is a serious concern. Special enclosures are generally required to reduce the noise from crushing and screening operations. Truck noise is often a significant problem and circuitous access roads and berms are often required.

Pit rehabilitation is a requirement for all operations in areas designated under the Pits and Quarries Control Act.. Increasingly stringent standards are adding substantially to quarry costs and thus to the costs of stone. However, operators recognize the value of rehabilitation as a wise corporate practice in light of increasing land use competition, especially in southern Ontario.

## STONE SPECIFICATIONS

Specifications for crushed limestone for various uses have been developed based on the use of the material as either coarse or fine aggregate. The most important specifications deal with the use of limestone aggregates as road building materials and as concrete aggregate for building construction.

### CLASSIFICATION

Aggregate is defined as coarse if it is retained on a seive that has openings with sides of 4.75 mm (No. 4 mesh). Fine aggregate is the material that passes. Typically, road construction requires 50% coarse and 50% fine aggregates; concrete and concrete products require 55% coarse and 45% fine aggregates. Crushed stone is interchangeable with gravel for many applications but not all. The most important specifications are those of particle size and distribution, and particle shape, although physical and chemical properties are also important.

The gradation of fine aggregate in asphalt and concrete mixes is critical. Specifications permit a fair range in gradation but require a high degree of uniformity in the continuing supply. In concrete, the colour and texture of the finished product is materially affected by the nature of the aggregate, particularly of the fine aggregate.

The proportion of fine material produced in a crushed stone operation depends on several factors, primarily the degree of crushing. Typical crushed limestone plants produce approximately 25% fine aggregate, not all of which is salable. Some plants, due to equipment factors and the physical characteristics of the stone may produce 35% or more fine aggregate. The unsalable proportion of this output can build quickly and create a costly storage problem. If it is never sold, the whole cost of the operation, including the cost of disposal of the unwanted material, must be borne by the revenue from other products.

The gradation and angularity of a typical quarry fine product, while generally resembling sand in its size range and quite consistent in its makeup, does not make its use in concrete or asphalt readily acceptable. Its best use is in base course materials where its nature contributes to compactability. However, problems are encountered when too much extreme fine content impedes the drainage of water from the base.

"Manufactured sand" can be produced by the crushing and grinding of stone. It is a practical method for increasing the proportion of fine aggregate within certain limits. However, the method is highly energy intensive and the product, while satisfactory for some uses such as mass concrete, is unsuitable for many uses due to its harsh angular shape. The most significant difficulty is caused by the large amount of extreme fine sizes, below 200 mesh, that is produced. The amount of this material can exceed 20% and its disposal is costly and difficult.

In fine aggregates the gradation is usually the most important quality factor. If that is controlled, the material is usually acceptable.

In coarse aggregate, the desired size can generally be produced by the degree of crushing, but many physical and chemical specifications must also be satisfied. Various deleterious materials such as chert, shale or siltstone may be present in a quarry face which may restrict or totally prevent the use of such materials. Specifications that do not permit the use of lower quality material result in higher prices. However, the cost of aggregate is usually such a small part of the total construction cost that compromising the expected life of the finished product by using cheaper materials is rarely a good practice.

## CONSTRUCTION AGGREGATE SPECIFICATIONS

Considerations in the assessment of aggregate for construction purposes include the following:

- ☐ Strength and hardness

  principally related to density, porosity, and homogeneity of a deposit

- ☐ Cleanness

  free from dust and fines such as clay, silt and soil

- ☐ Particle shape

  the particles should be as cubic shaped as possible with no laminations or incipient cracks. Flat elongate particles are not desirable as they exhibit poor interlocking and contribute to excessive voids.

- ☐ Chemical soundness

  a minimum content of soluble minerals, impurities such as sulphates and susceptibility to alkali–reactivity – particularly important where aggregate is used in concrete

In Ontario, the use of limestone aggregate in road construction is governed by Ontario Provincial Standard Specifications (OPSS) developed by the Ministry of Transportation. The following specifications cover the main aggregate applications:

1001 – aggregates – general, fine and coarse
1002 – aggregates – concrete
1003 – aggregates – hot mix asphaltic concrete
1004 – aggregates – miscellaneous
1010 – aggregates – Granular A, B, and M and select subgrade material

These specifications are supplemented by specified test procedures and specifications developed by the Canadian General Standards Board (CGSB), the Canadian Standards Association (CSA), and the American Society for Testing and Materials (ASTM) for special situations. The OPSS prescriptions for aggregates are summarized in Table 3.1.

The most significant factors in the specifications relate to the following:

- gradation of fine and coarse aggregate
- percent of flat and elongate particles in the batch
- physical test requirements such as Los Angeles Abrasion, Magnesium Sulphate Soundness, Petrographic Number, Absorption and Plasticity Index
- chemical requirements such as alkali limits for alkali–silica and alkali–carbonate reactive rock

An additional criteria which is being developed relates to the skid resistance of aggregate. The Ministry of Transportation uses a measure of the ability of an aggregate to retain or develop microtexture called the Polished Stone Value (PSV) test. Wear resistance of the aggregate is measured by the Aggregate Abrasion Value (AAV).

Table 3.2 illustrates a typical section through a road. The thickness and composition of each layer will be dependent on the level of traffic and the nature of the traffic expected for the road, as well as the nature of the ground conditions and the climatic conditions.

Crushed limestone aggregate is used in road base below the asphaltic driving course. A well graded material results in greater interlock between particles thereby increasing the frictional strength and load bearing capacity of the road. Limestone particles must be resistant to freeze–thaw action. This avoids the generation of excess fines which results in decreased permeability and strength. Physical and gradation requirements for these materials are covered by OPSS 1010 and OPSS 1001 and refer to Granular A, B, M, and select subgrade material.

## Table 3.1. ONTARIO PROVINCIAL STANDARD SPECIFICATIONS FOR ROAD CONSTRUCTION AGGREGATE.

### OPSS 1002 - SPECIFICATIONS FOR CONCRETE AGGREGATES. Gradation Requirements For Fine Aggregates.*

| MTO Sieve Designation | Percentage Passing |
|---|---|
| 9.5 mm | 100 |
| 4.75 mm | 95-100 |
| 2.36 mm | 80-100 |
| 1.18 mm | 50-85 |
| 600 µm | 25-60 |
| 300 µm | 5-30 |
| 150 µm | 0-10 |
| 75 µm | 0-3 Natural Sand<br>0-6 Manufactured Sand |

**MTO Lab Test No. LS 602.*

### Gradation Requirements - Coarse Aggregates For Structural Concrete, Sidewalks, Curb & Gutter.*

| Nominal Maximum Size | 19.0 mm | 13.2 mm | 9.5 mm** |
|---|---|---|---|
| **MTO Sieve Designation** | **Percentage Passing** | | |
| 53.0 mm | | | |
| 37.5 mm | | | |
| 26.5 mm | 100 | | |
| 22.4 mm | - | | |
| 19.0 mm | 90-100 | 100 | |
| 16.0 mm | 65-90 | - | |
| 13.2 mm | - | 90-100 | 100 |
| 9.5 mm | 20-55 | 40-70 | 85-100 |
| 4.75 mm | 0-10 | 0-15 | 10-30 |

**MTO Lab Test No. LS 602*

***Not more than 10% of 9.5 mm nominal maximum size material shall pass the 2.36 sieve.*

### Gradation Requirements - Coarse Aggregates For Concrete Pavement Or Base.*

| Nominal Maximum Size | 37.5 mm | 19 mm | Combined |
|---|---|---|---|
| **MTO Sieve Designation** | **Percentage Passing** | | |
| 53.0 mm | 100 | - | 100 |
| 37.5 mm | 90-100 | - | 95-100 |
| 26.5 mm | 20-55 | 100 | - |
| 19.0 mm | 0-15 | 90-100 | 35-70 |
| 13.2 mm | - | - | - |
| 9.5 mm | 0-5 | 20-55 | 10-30 |
| 4.75 mm | - | 0-10 | 0-5 |

**MTO Lab Test No. LS 602.*

### OPSS 1003 - SPECIFICATIONS FOR HOT MIX ASPHALTIC CONCRETE. Gradation Requirements For Total Fine Aggregate.*

| MTO Sieve Designation | Percentage Passing HL 1 & 3 | HL 2 | HL 4 & 8 |
|---|---|---|---|
| 9.5 mm | 100 | 100 | 100 |
| 4.75 mm | 90-100 | 85-100 | 85-100 |
| 2.36 mm | 70-100 | 70-90 | 60-100 |
| 1.18 mm | 50-90 | 50-75 | 34-90 |
| 600 µm | 30-70 | 30-55 | 17-70 |
| 300 µm | 15-40 | 15-35 | 9-40 |
| 150 µm | 5-15 | 5-15 | 3-15 |
| 75 µm | 0-5 | 3-8 | 0-7 |

**MTO Lab Test No. LS 602.*

### Gradation Requirements For Coarse Aggregate.*

| MTO Sieve Designation | Percentage Passing HL 1 & 3 | HL 4 | HL 8 |
|---|---|---|---|
| 26.5 mm | - | - | 100 |
| 19.0 mm | - | 100 | 90-100 |
| 16.0 mm | 100 | 96-100 | 65-90 |
| 13.2 mm | 96-100 | 67-86 | - |
| 9.5 mm | 50-73 | 29-52 | 20-55 |
| 4.75 mm | 0-10 | 0-10 | 0-10 |

**MTO Lab Test No. LS 602.*

### Physical Requirements For Coarse Aggregate.

| MTO Lab Test | MTO Lab Test # | HL Type 1 | 3 | 4 | 8 |
|---|---|---|---|---|---|
| Los Angeles Abrasion, % Maximum Loss | LS 603 | 15 | 35 | 35 | 35 |
| Magnesium Sulphate Soundness, 5 cycles % Maximum Loss | LS 606 | 5 | 12 | 12 | 15 |
| Absorption, % Maximum | LS 604 | 1.0 | 1.75 | 2.0 | 2.0 |
| Petrographic Number, HL Max. | LS 609 | 100 | 135 | 160 | 160 |
| Loss by Washing (Passing 75 µm Sieve), % Maximum | LS 601 | *1.0 | *1.3 | *1.3 | *1.3 |
| Flat and Elongated Particles, % Maximum | LS 608 | 20 | 20 | 20 | 20 |
| Percentage Crushed % Maximum | LS 607 | 100 | 60 | 60 | 60 |

**When quarried rock is used as a source of coarse aggregate, a maximum of 2 percent passing the 75 µm sieve shall be permitted.*

**Table 3.1. CONTINUED.**
**OPSS 1002 - SPECIFICATIONS FOR CONCRETE AGGREGATES. Physical Requirements - Coarse Aggregates.**

| MTO Lab Test | MTO Lab Test Number | Acceptance Requirement | |
|---|---|---|---|
| | | Concrete Pavement | Concrete Structures Sidewalk, Curb and Gutter, and Base |
| Material finer than 75 µm Sieve, by washing, % Maximum, | LS 601 | | |
| - for gravel | | 1 | 1 |
| - for crushed rock | | 2 | 2 |
| Los Angeles Abrasion, % Maximum Loss | LS 603 | 35 | 50 |
| Absorption, % Maximum | LS 605 | 2 | 2 |
| Magnesium Sulphate Soundness, 5 cycles, % Maximum Loss | LS 606 | 12 | 12 |
| Flat and Elongated Particles, % Maximum | LS 608 | 20 | 20 |
| Petrographic Number, Maximum | LS 609 | 125 | 140 |

**OPSS 1010 - SPECIFICATIONS FOR ROAD BASE AGGREGATES. Physical Requirements.**

| Physical Test | Granular A | Granular B | | Granular M | Select Subgrade Material | MTO Lab Test Number |
|---|---|---|---|---|---|---|
| | | Type I | Type II | | | |
| Los Angeles Abrasion, Loss % Maximum | 60 | N/A | N/A | 60 | N/A | LS 603 |
| Petrographic No., Granular, Maximum | 200 | *250 | 250 | 200 | *250 | LS 609 |
| Plasticity Index | 0 | 0 | 0 | 0 | 0 | LS 704 |
| Percentagae Crushed Minimum | 50 | N/A | 100 | 50 | N/A | LS 607 |

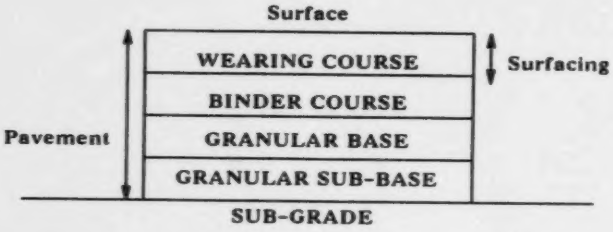
**The Petrographic No. requirements will be waived if the material has more than 80% passing the 4.75 mm sieve.*

**Gradation Requirements***.**

| MTO Sieve Designation | Percentage Passing by Mass | | | | |
|---|---|---|---|---|---|
| | Granular A | Granular B | | Granular M | Select Subgrade Material |
| | | Type I**** | Type II**** | | |
| 150 mm | N/A | 100 | 100 | N/A | 100 |
| 37.5 mm | N/A | N/A | N/A | N/A | N/A |
| 26.5 mm | 100 | 50-100 | 50-100 | N/A | 50-100 |
| 19 mm | 85-100<br>*(87-100) | N/A | N/A | 100 | N/A |
| 13.2 mm | 65-90<br>*(75-95) | N/A | N/A | 75-95 | N/A |
| 9.5 mm | 50-73<br>*(60-83) | N/A | N/A | 55-80 | N/A |
| 4.75 mm | 35-55<br>*(40-60) | 20-100 | 20-55 | 35-55 | 20-100 |
| 1.18 mm | 15-40 | 10-100 | 10-40 | 15-40 | 10-100 |
| 300 µm | 5-22 | 2-65 | 5-22 | 5-22 | 5-95 |
| 150 µm | N/A | N/A | N/A | N/A | 2-65 |
| 75 µm | 2-8<br>**(2-10) | 0-8<br>**(0-10) | 0-10 | 2-8<br>**(2-10) | 0-25 |

(*) *Where the aggregate is obtained from an iron blast furnace slag source.*
(**) *Where the aggregate is obtained from a quarry or slag source.*
(***) *MTO Lab Test No. LS 602.*
(****) *When Granular B is used for granular backfill for pipe subdrains, 100% of the material shall pass the 37.5 mm sieve.*

**Table 3.2. A TYPICAL CROSS-SECTION THROUGH AN ASPHALT ROAD.**



| | |
|---|---|
| Wearing course | A stable weather resistant running surface which has to withstand the abrasive forces of traffic and provide a degree of skid resistance |
| Binder course | Provides strength to the pavement while providing an even, well regulated surface for the wearing course. |
| Granular base | The load-bearing and strengthening component of the pavement. Protects wearing and binder course from frost action. |
| Granular sub-base | Lowest layer of the pavement. Acts as the principal foundation for the subsequent road profile, and protects overlying pavement structure from frost. |
| Sub-grade | Usually natural soil, exposed rock formation, or rock fill. |

*Modified after Power, 1985.*

Aggregates used in concrete pavement or base are governed by OPSS 1002. Coarse aggregate for this application has a nominal minimum size of 4.75 mm. Fine aggregate has a nominal maximum size of 9.5 mm and a nominal minimum size of 150 microns. The physical requirements for coarse aggregate require a maximum Los Angeles Abrasion and Impact Loss of 35% and a maximum Magnesium Sulphate Soundness Loss of 12%. The percent of flat and elongate particles should not exceed 20%.

Aggregate for use in asphaltic mixes for road surfaces must conform to the requirements of OPSS 1003. These aggregates are referred to as HL1, 2, 3, 4 and 8. Secondary highways with less than 2,500 AADT/lane (average annual daily traffic/lane) use HL3 (hot laid) and HL4. HL3 aggregates have a maximum size of 13.3 mm, allowing a minimum mat thickess of about 25 mm. HL4 aggregates have a maximum size of 16 mm, allowing a minimum mat thickness of about 30 mm, but normally 44 mm.

On highways with more than 2,500 AADT/lane the types of asphalt aggregates used are designated HL1, DFC (dense friction coarse) and OFC (open friction coarse). HL1 asphalt has the same gradation as HL3, only the nature of the stone is different. DFC has angular fine aggregate to increase stability. OFC is an open graded mix, allowing internal drainage through the matrix rather than over the pavement surface. It is used on very high volume, urban highways because of its low tire noise characteristics.

Aggregates for HL3 and HL4 have no requirements respecting their frictional properties, except for northern Ontario. In this region, most of the locally available aggregates are of igneous or metamorphic origin, with hard wear-resistant minerals. These aggregates generally give good frictional properties in contrast to pavements made with carbonates of low wear-resistance. Drivers in northern Ontario become accustomed to the good friction supplied by local aggregates and do not adjust their driving habits to accommodate poorer performing materials. As a result, in many parts of northern Ontario the use of aggregates containing more than 40% carbonates is prohibited.

The selection of the coarse aggregate for HL1, DFC and OFC pavements is based on the actual performance of the aggregate in test sites. The following aggregate types are used: trap rock (metavolcanic), steel slag, blast furnace slag, dolomitic sandstone and some igneous gravels from the north shore of Lake Huron. Table 3.3 illustrates the principal types and properties of surface coarse asphalt mixes used in Ontario.

The skid resistance of a road surface is determined by both its macrotexture; i.e., the projection of coarse aggregate particles above the matrix, and its microtexture, i.e., the surface texture of the particle. Good macrotexture is required to break the water film on the road surface at high speed and to provide bulk drainage. It is measured by the aggregate's ability to withstand abrasion, the Aggregate Abrasion Value (AAV) test. A good microtexture is needed at all driving speeds to penetrate the thin water film and come in contact with the tire. This is measured by the Polished Stone Value (PSV) test. Low AAV values and a minimum PSV of 50 have been reported as being desirable for high density roads in Ontario. In the United Kingdom high traffic volume road surfaces are constructed with aggregates having a maximum AAV of 12 and a minimum PSV of 55–65. Very few, if any, carbonate materials are able to pass these requirements, except for dolomitic sandstone (from the March Formation), which has been found to be the best, naturally occurring skid-resistant material in Ontario as determined by the PSV test. This rock is found in eastern Ontario. This material also appears to provide the

**Table 3.3. PRINCIPAL TYPES OF SURFACE COURSE ASPHALT MIX USED IN ONTARIO.**

| Mix Type | Maximum Stone Size | Normal Stone Content % | Fine Aggregate Type | Annual Average Daily Traffic |
|---|---|---|---|---|
| HL4 | 16.0 mm | 45-50 | Natural sand | <2500 |
| HL3 | 13.2 mm | 45-50 | Natural sand | <2500 |
| HL1 | 13.2 mm | 45-55 | Natural sand | >2500<br><5000 |
| D.F.C. | 13.2 mm | 45-55 | Angular screenings | >5000 |
| O.F.C. | 9.5 mm | 65-70 | Angular screenings | >5000<br>(Urban expressways) |

*Modified after Rogers, 1983.*

lowest cost per tonne on a laid–down basis of any of the better skid–resistant materials, as shown in Figure 3.2.

## CONCRETE AGGREGATE

Aggregates for use in concrete, exclusive of that for road building, are governed by OPSS 1002, CSA specification CAN3–A23.1–M77 and/or ASTM specification C33–82. The desirable properties of concrete aggregates are that they be essentially clean, and uncoated, consisting of properly shaped particles of strong, durable material. When incorporated in concrete, they should satisfactorily resist changes such as cracking, swelling, softening, leaching, or chemical alteration, and should not contain contaminating substances which might contribute to the deterioration, loss in strength, or unsightly appearance of the concrete.

Many carbonate rocks produce good quality aggregates. However, grain size or the presence of other materials can affect the overall quality. Carbonate rocks can have very porous structures due to leaching of soluble minerals (evaporites) or the weathering out of argillaceous impurities. They can also contain fossils which may increase the porosity of the rock.

Extremely fine grained limestones (lithographic limestones) can give reduced strength in concrete due to poor bond strength between the rock and cement paste.

The evaporite minerals gypsum and anhydrite can occur in calcareous rocks as nodules. Gypsum can delay the setting time of concrete and can also cause concrete expansion.

Anhydrite absorbs water readily causing volume increases as well as the formation of secondary gypsum. Gypsum nodules are found in some quarries within the Niagara Escarpment between Queenston and Hamilton.

Coarse crystalline marbles are weak when subject to stress. This is a result of poor intergranular bonds. Ultimately, the compressive and flexural strengths of a concrete containing these aggregate types will be reduced.

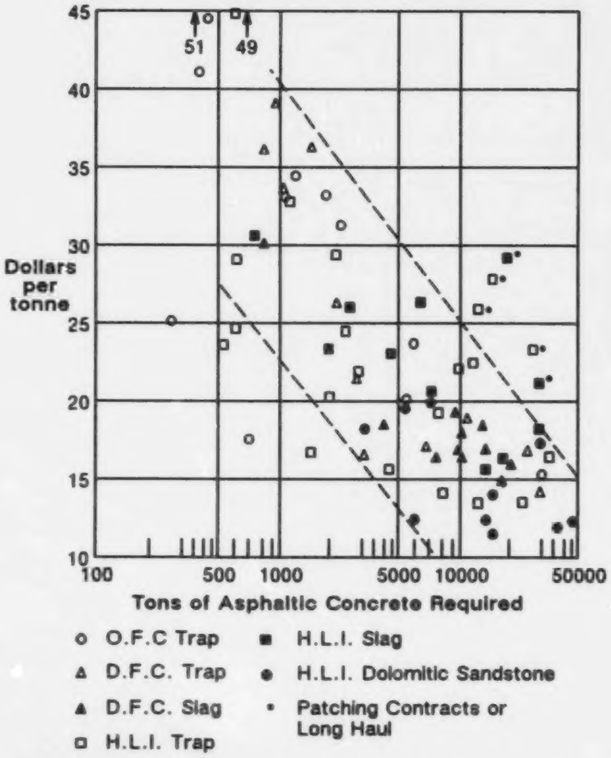


**Figure 3.2. COST PER TON OF MIX PLOTTED AGAINST QUANITITY FOR 1979-1981 CONTRACTS.** *Source: Rogers, 1983.*

Some marbles may also have peculiar and uneven rates of thermal expansion and contraction which can make them incompatible with the cement paste in a concrete at low temperatures. This effect can lead to rapid deterioration of a concrete.

### ALKALI-AGGREGATE REACTIVITY

Certain Ontario carbonate aggregates react with the alkalies of cement ($Na_2O$ and $K_2O$) which produces an undesirable expansion leading to the cracking and deterioration of concrete. Cracking also creates channels for water movement in the concrete leading to an increase in saturation and reduced freeze–thaw durability. The higher the alkali content of the cement and the higher the cement content of the concrete, the greater the rate of expansion and cracking. It is possible to use special low alkali cement or other corrective measures but it is better to use non reactive aggregates. It is most important that potentially reactive aggregates are recognized, and are properly investigated before they are used in concrete.

These reactions can be grouped into two types with Ontario limestones (1) alkali–carbonate, and (2) alkali–silica.

#### Alkali–Carbonate Reaction

Rocks of the Gull River Formation (Lake Ontario Basin and Ottawa/St. Lawrence Lowlands) are alkali–carbonate reactive. They are comprised of beds of fine grained dolomitic limestone with a significant clay mineral content.

This reaction only occurs with coarse aggregate from quarries. Only certain beds or levels within the quarry may be reactive. A number of different techniques may be used to identify the potential reactivity of these materials, of which the simplest method is the Quick Chemical Test (MTO LS–615). This test measures the relative amount of dolomite and clay content within the rock. This test can be completed in a few days. The results allow the immediate acceptance of most aggregates.

If an aggregate fails the Quick Chemical Test, more lengthy testing is called for, specifically, the Concrete Prism Expansion Test (CAN3– A23.2–14A, 1986). This test usually takes one year before a final result is obtained.

Other techniques are also used, such as the Rock Cylinder Expansion Test (ASTM C586) or detailed examination under the microscope. These techniques are usually used in the exploration of new quarries and are not normally used for accepting aggregate stockpiles.

#### Alkali–Silica Reaction

The main alkali–silica reactive mineral found in Ontario limestones is chalcedony ($SiO_2$). Rocks of the Bobcaygeon Formation in the Lake Ontario Basin and Ottawa/St. Lawrence Lowlands are known to be alkali–silica reactive due to the presence of small amounts of chalcedony.

The Mortar Bar Test (ASTM C227) is employed with suspect aggregates. Results are usually obtained after 3 or 6 months. The Quick Chemical Test (ASTM C289) is not practical when significant amounts of carbonate materials are present so is not useful for evaluating the alkali–silica reactivity of these limestones.

The Ontario Ministry of Transportation has compiled information and performed research on the alkali reactivity of concrete aggregates. Several limited distribution reports have been published on the topic. For more detailed information, the reader is referred to the Soils and Aggregates Section of the Engineering Materials Office, Ministry of Transportation, Downsview, Ontario.

### RAILWAY BALLAST

Specifications for railway ballast are generally established by the American Railway Engineering Association (AREA). The AREA specifies material in the size range 64–19 mm, although 5% to 10% of the ballast may be as small as 9.5 mm. The ballast must have an abrasive resistance value equal to or less than 40% based on the Los Angeles Abrasion test.

The increased use of concrete sleepers may force a gradual change from the use of limestone as ballast. Concrete sleepers reduce the relative resistance of the ballast to point loading by concentrating the vertical and horizontal forces on individual units. This creates too heavy a load on the aggregate resulting in the production of excess fines and a gradual rounding of the aggregate. Reduced particle interlock because of rounding, and the generation of fines which trap water, will result in decreased strength in the ballast and increase the incidence of frost heaving. Preferable materials in such cases are granitic rocks, trap rock, and blast furnace slag.

## OTHER USES

Specifications for other uses of limestone aggregate such as roofing granules, stucco dash, poultry grit, etc., are generally set by ASTM. Roofing granules for built–up roofs are generally in the size range of 19.2 to 2.4 mm. Poultry grit varies from 9.5 mm coarse material to 3.2 mm fine aggregate. Crushed limestone for use in flue–gas desulphurization is generally specified to be 85% passing 325 mesh. Filter beds for sewage treatment plants use stone of 3.8 to 6.35 cm size (or 5.1–7.6 cm for high rate filters) with very low tolerances for plus or minus size material. Soundness requirements are very strict and low moisture absorption is required.

# Cement

The term "cement" most commonly refers to hydraulic cement, especially portland cement. Hydraulic cements have the property of hardening under water and are the chief binding agents for concrete and masonry. Portland cement, originally patented by Joseph Aspdin in England in 1824, is the predominant variety of hydraulic cement, accounting for about 95% of all cement produced in North America; slag cement and masonry cement used for stucco and mortar account for most of the balance.

Hydraulic cements were originally discovered in ancient times. The Egyptians calcined an impure gypsum containing calcium carbonate to obtain a cementing material for use in the construction of the Great Pyramid about 2,600 B.C. The Greeks and the Romans pulverized volcanic material and mixed it with sand and lime to make a mortar which exhibited great strength and durability under water.

The art of producing cement was lost during the decline of the Roman Empire. In 1756, John Smeaton rediscovered the lost art when he found that clay, when contained in or added to limestone and the volcanic material pozzolana, produced a hydraulic cement. Joseph Parker, in 1796, patented a hydraulic cement produced from limestone containing nodules of clay, and pulverized old bricks and tiles. This material was called Roman cement. Finally, in 1824, Joseph Aspdin patented a process for the production of a hydraulic cement based on the mixing and calcination of clay, sand, and limestone. This material was called portland cement because the set material resembled the building stone quarried from the Isle of Portland in England.

In North America, testing of limestones for use as mortar in the construction of the Erie Canal led to the discovery of an argillaceous limestone in Madison County, N.Y. This material was called cement rock because it contained raw materials in proportions required for the production of "natural cement". Rapid expansion of the system of canals in eastern North America resulted in an expansion of the natural cement industry. In about 1850, however, concrete became a major building material and the superior qualities of portland cement resulted in it becoming an important import into North America.

In 1871, David Taylor of Pennsylvania patented a cement equal to the imported portland cement. The material was produced from argillo–magnesium and argillo–calcareous limestone burned at a high temperature to a state of vitrification. The ground clinker made an excellent cement. Portland type cement production increased rapidly in subsequent years and gradually displaced natural cement production. By 1920, most of the natural cement plants in North America had been closed or converted to portland cement production.

The first cement produced in Ontario was derived from natural cement rock. Production probably began in the early 1840s at Thorold at the quarry of John Battle, which was opened in 1841. This quarry was later called the Thorold Hydraulic Cement Works and operated until 1891. During the period from about 1880 to 1907 there were five natural cement producers in the province. In addition to the Thorold operation, natural hydraulic cement was produced by Rathbun and Company at its plant at Strathcona (Napanee Mills) beginning in 1880; by the Toronto Lime Company at Limehouse; by Queenston Cement Works at Queenston beginning in 1881; and by F. Schwendiman in Barton Township near Hamilton beginning in 1894.

Portland cement production based on marl began in 1886 at Strathcona, by Rathbun and Company. Marl–derived portland cement flourished from 1886 to 1919, with 14 plants being active. Most of the plants were located in Grey County (7), with other plants being located in Hastings, Lennox & Addington, Victoria, Peterborough, Perth, and Dufferin counties.

The first limestone–based portland cement plant in Ontario was built in 1905 by the Belleville Portland Cement Company at Point Anne near Belleville. In 1908, Lehigh Portland Cement Co. also built a plant at Point Anne. This was followed by plants at Port Colborne (1908, Canadian Portland Cement), St. Marys (1912, St. Marys Cement), Hanover (1920, Hanover Portland Cement), and Lakefield (1927, Canada Cement Company).

In 1909 severe competition and over capacity in the cement industry prompted the formation of the Canada Cement Company. This company was formed as the result of a merger of four of the marl cement producers and three of the limestone portland cement producers, plus two Quebec–based cement plants. Competition in the Ontario cement industry remained limited until the mid–1950s, when several new producers such as Lake Ontario Cement and St. Lawrence Cement Company entered the market.

Current North American clinker production capacity is approximately 136.5 million tonnes, distributed 63% (86.0 million tonnes) in the U.S., 12% (16.4 million tonnes) in Canada, 21% (28.7 million tonnes) in Mexico, and 4% (5.4 million tonnes) elsewhere.

## TYPES OF CEMENTS

Portland cement is produced by heating a properly portioned mixture of finely ground raw materials containing calcium carbonate, silica, alumina and usually iron oxide, to a sintering temperature of about 1,480°C in a kiln. Partial fusion occurs at this temperature, resulting in a product called clinker. Chemically, clinker comprises four main phases of various proportions of tricalcium silicate ($3CaO.SiO_2$, abbreviated C3S), dicalcium silicate ($2CaO.SiO_2$, or C2S), tricalcium aluminate ($3CaO.Al_2O_3$, or C3A), tetracalcium aluminoferrite ($4CaO.Al_2O_3.Fe_2O_3$, or C4AF), minor amounts of calcium sulphate ($CaSO_4$), and usually, but not necessarily, magnesia (MgO), lime (CaO), and various alkalis, depending on raw materials used. The clinker is ground to a fine powder with a small amount, 2% to 5%, of calcium sulphate, usually gypsum or anhydrite, to make portland cement.

There are several varieties of portland cement which are classified mostly on the proportions of C3S, C2S, and C3A in the cement. The five most common types of portland cement are:

□ Normal Portland – Type 10 (Canada); Type I (U.S.)

□ High Early Strength Portland – Type 30 (Canada); Type III (U.S.)

similar to normal portland, but is normally ground finer and slightly altered in composition

□ Sulphate Resisting Portland – Type 50 (Canada); Type V (U.S.)

composition is modified to provide increased resistance to sulphate–bearing waters

□ Moderate Portland Cement – Type 20 (Canada); Type II (U.S.)

provides moderate sulphate resistance and moderate heat of hydration

□ Low–Heat–of–Hydration Portland – Type 40 (Canada); Type IV (U.S.)

chemical composition is adjusted to reduce the heat of hydration and provide a slower rate of strength development than normal portland

Moderate portland and low–heat–of–hydration portland cements are for use in concrete to be poured in large volumes such as in dam construction.

Portland cements are also available in an air–entrainment formulation in which a small amount of an air–entrainment agent has been added during grinding. The agent produces minute, well–distributed, completely separated air voids that protect the concrete from freeze–thaw damage. The agents used are:

- alkali salts of wood resins, soluble in coal tar hydrocarbons (i.e. benzene, toluene, etc.) and insoluble in petroleum solvents
- synthetic detergents of the alkyl–aryl sulphonate type, the alkyl group being derived from a petroleum distillate and the aryl group usually being a sulphonated benzene or naphthalene ring. The usual product is the sodium salt
- calcium lignosulphonate from sulphite pulping
- sodium salts of cyclo–paraffin carboxylic acids such as naphthenic acid
- calcium salts of glues and other proteins obtained in the tanning process
- alkali or triethanolamine salts of fatty acids derived from fats and vegetable oils and from the alkali pulping process
- triethanolamine salts of sulphonated aromatic hydrocarbons derived from petroleum.

White cement is an ordinary portland cement made from iron–free materials so that its colour is white instead of grey. The clinker is burned in a reducing flame in the kiln and rapidly quenched in a water spray to keep any iron in the ferrous state to avoid coloration by ferric iron compounds. The clinker is ground with high purity gypsum using ceramic balls and liners in grinding mills, although there is a trend to the use of high–chromium alloys for use as liners and grinding media. White cement is used in decorative concrete including terrazzo, highway lane markers, and architectural concrete.

Masonry cement is a hydraulic cement for use in mortars for masonry construction. It contains one or more of the following materials: portland cement, portland–pozzolan cement, slag cement, or hydraulic lime, usually with hydrated lime, limestone, chalk, calcareous shale, talc, slag, or clay interground for plasticity. The material is marketed under the following proprietary names:

- mortar cement
- mortar mix
- mason's cement
- brick cement
- masonry cement.

Portland–blast furnace slag cement is an interground mixture of portland cement clinker and granulated blast furnace slag in which the amount of the slag constituent is between 25% and 70% of the total weight of the blended cement. It is used for general concrete construction.

Portland–pozzolan cement is an intimate and uniform blend of portland cement or portland–blast furnace slag cement and fine pozzolan. The pozzolan constituent ranges from 15% to 40% of the total weight of the blended cement and is a finely divided aluminous and siliceous material that reacts with calcium hydroxide in the presence of water to form a material with cement–like properties. Fly ash from coal fired power plants is a typical example. Natural pozzolanic materials include some diatomaceous earths, opaline cherts and shales, tuffs, volcanic ash, and pumices.

Slag cement is a finely divided material consisting of an intimate and uniform blend of granulated blast furnace slag and hydrated lime in which the slag constituent is at least 70% of the total weight of the blended cement.

Oil–well cement is used to seal oil and gas wells at pressure up to 18,000 psi and temperatures up to 180°C. The cements are required to remain fluid for up to 4 hours and then to set rapidly. Setting time is controlled by reducing C3A to nearly zero or adding to portland cement some retarder such as starches or cellulose products, sugars, and acids or salts of acids containing one or more hydroxyl groups.

Expansive cement is a hydraulic cement that expands slightly on hardening, or has no net shrinkage on subsequent air–drying. Three types of expansive cements are recognized in the American Society for Testing and Materials (ASTM) specifications, all of which depend upon the formation of calcium sulphoaluminate hydrate to cause expansion equal to or greater than shrinkage that would normally occur during the hardening process.

Set–regulated cement is a hydraulic cement where the setting time can be controlled from 1 to 10 minutes and very high early strengths develop. The cement contains from 1 to 30 weight percent of $11CaO.7Al_2O_3.CaF_2$. Slip–formed structures, highway repairs, underwater patching, and manufacture of pre–stressed, precast forms are principal applications.

Aluminous cement, also known as high–alumina cement, calcium aluminate cement, or "Ciment Fondu" is manufactured by heating until molten, or by sintering, a mixture of high–purity bauxite and limestone with a very low silica and magnesium content. The product is cooled and finely ground. Special applications of aluminous cement are based on its rapid–hardening qualities, resistance to sulphate action, and refractory properties when used as "castable refractories" and mortars for furnaces and kilns. The material is black in colour.

Specifications for portland cements used in Canada are published by the Canadian Standards Association (CAN 3–A5–M83). Masonry cement used in Canada should conform to the CAN 3–A8–M83 specification. Blended hydraulic cements are covered by CAN 3–A362–M83. Cement types manufactured in Canada but not covered by the CSA standards generally meet the appropriate specifications of the ASTM. A comparison of Canadian and U.S. cement specifications is provided in Table 3.4. It will be noticed that Canadian specifications allow for a larger percentage of alkali materials in the cement than do U.S. specifications. This difference in specifications has an impact on the operations and market opportunities available to some of the Ontario cement manufacturers.

Cembureau, the European Cement Association, has published Cement Standards of the World – Portland Cement and its Derivatives, in which standards are compared. Cembureau also publishes the World Cement Directory, which lists production capacities by country and by company.

## CEMENT MANUFACTURE – MATERIALS

Portland cement is prepared by igniting a mixture of raw materials, one of which is mainly composed of calcium carbonate and the other of aluminum silicates. The most typical materials answering this description are limestone and clay, both of which occur in nature in a great number of varieties. In Canada limestone represents about 84% of the total raw material requirement, the balance being comprised of clay, shale, gypsum, sand or silica, and iron oxide.

Limestone for cement use is obtained from sedimentary formations of marine origin from virtually every geologic age. Argillaceous limestone, often called cement rock, and containing ingredients for cement manufacture in approximately the required amount, is extensively used in Ontario. The maximum magnesium oxide (MgO) allowed in portland cement is 5% in both Canada and the United States.

Noncalcareous materials necessary for manufacturing clinker are silica ($SiO_2$), alumina ($Al_2O_3$), and iron oxide ($Fe_2O_3$). Many limestone deposits contain chert, a form of silica, and some contain iron minerals. Sand, quartzite, and sandstones from sedimentary deposits are used to maintain the proper silica ratio, but most of the silica is added in the form of aluminum silicates in clay and shale. Iron ore and mill scale are the predominant sources of iron oxide. Fly ash is being increasingly used as a substitute argillaceous raw material. Blast furnace slag is utilized for both the silica and alumina content and as a source of iron oxide.

In addition to the raw materials used for making clinker, calcium sulphate ($CaSO_4$) in the form of gypsum or anhydrite, is added during the grinding of clinker in quantities up to 5%, to impart set–retardant properties to the finished cement.

Table 3.5 provides analyses of typical cement raw materials. Table 3.6 shows the distribution of cement raw materials used in Canada and the United States. It is assumed that Ontario cement manufacturers employ a mix of raw materials similar to that used in the rest of Canada in the production of their products.

## CEMENT MANUFACTURE – TECHNOLOGY

### EXPLORATION AND DEVELOPMENT

The relative abundance of limestone and other calcareous materials, shales, and clays narrows the prospecting and exploration work mostly to delineating the size and chemical uniformity of the deposits. Portland cement cannot contain more than 5% MgO as larger amounts promote the formation of periclase, which expands and

Table 3.4a. COMPARISON OF CEMENT SPECIFICATIONS.

| | Canada Type | | | | | United States Type | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Factor | 10 | 20 | 30 | 40 | 50 | I | Ia | II | IIa | III | IIIa | IV | V |
| **Chemical requirements** | | | | | | | | | | | | | |
| $SiO_2$, min., % | – | – | – | – | – | – | | 20.0 | | – | | – | – |
| $Al_2O_3$, max., % | – | – | – | – | – | – | | 6.0 | | – | | – | – |
| $Fe_2O_3$, max., % | – | – | – | – | – | – | | 6.0 | | – | | – | – |
| MgO, max., % | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 6.0 | | 6.0 | | 6.0 | | 6.0 | 6.0 |
| $SO_3$, max., % | | | | | | | | | | | | | |
| when $C_3A$ <7.5% | 3.0 | 3.0 | 3.5 | 2.5 | 2.5 | 3.0 | | 3.0 | | 3.5 | | 2.3 | 2.3 |
| when $C_3A$ >7.5% | 3.5 | – | 4.5 | – | – | 3.5 | | – | | 4.5 | | – | – |
| $C_3A$, max., % | – | 7.5 | – | 5.5 | 3.5 | – | | 8.0 | | 15 | | 7 | 5 |
| $C_3S$, max., % | – | – | – | – | – | – | | – | | – | | 35 | – |
| $C_4AF + 2(C_3A)$ | – | – | – | – | – | – | | – | | – | | – | 25 |
| L.O.I., max., % | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | | 3.0 | | 3.0 | | 2.5 | 3.0 |
| Insoluble residue, max., % | 1.0 | 0.7 | 0.7 | 0.7 | 0.7 | 0.75 | | 0.75 | | 0.75 | | 0.75 | 0.75 |
| **Optional chemical requirements** | | | | | | | | | | | | | |
| $C_3A$, max., % | | | | | | | | | | $8^1$, $5^2$ | | | |
| $C_3S + C_3A$, max., % | | | | | | | | | $58^3$ | | | | |
| Alkalis ($Na_2O$ + 0.658 $K_2O$), max., % (for low alkali cement) | | | | | | 0.60 | | 0.60 | | 0.60 | | 0.60 | 0.60 |

*[1] For moderate sulfate resistance [2] For high sulfate resistance [3] For moderate heat of hydration*
*Note: $C_3A$ limit for $SO_3$ in U.S. is 8.0%*
*Source: Canadian Standards Association and ASTM*

Table 3.4b. COMPARISON OF CEMENT SPECIFICATIONS.

| | Canada Type | | | | | United States Type | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Factor | 10 | 20 | 30 | 40 | 50 | I | Ia | II | IIa | III | IIIa | IV | V |
| **Physical requirements** | | | | | | | | | | | | | |
| Air content of mortar, min./max. % | – | – | – | – | – | –/12 | 16/22 | –/12 | 16/22 | –/12 | 16/22 | –/12 | –/12 |
| Fineness, | | | | | | | | | | | | | |
| Specific surface ($m^2$/kg)[1] | | | | | | 280 | | 280 | | 280 | | 280 | 280 |
| % passing 45 micron sieve, min. | 72 | 72 | – | – | 72 | | | | | | | | |
| Autoclave expansion, max., % | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.80 | | 0.80 | | 0.80 | | 0.80 | 0.80 |
| Compressive strength (MPa) at: 1 day | – | – | 12.5 | – | – | – | – | – | – | 12.4 | 10.0 | – | – |
| 3 days | 12.5 | 10.0 | 22.0 | 8.5 | 10.5 | 12.4 | 10.0 | 10.3 | 8.3 | 24.1 | 19.3 | – | 8.3 |
| 7 days[2] | 18.0 | 16.0 | – | – | 16.0 | 19.3 | 15.5 | 17.2 | 13.8 | – | – | 6.9 | 15.2 |
| 28 days[2] | 26.5 | 26.5 | – | 25.0 | 26.5 | 27.6 | 22.1 | 27.6 | 22.1 | – | – | 17.2 | 20.7 |
| 91 days | – | – | – | 33.0 | – | – | – | – | – | – | – | – | – |
| Setting times[3] | | | | | | | | | | | | | |
| min., minutes | 45 | 60 | 45 | 90 | 60 | 45 | | 45 | | 45 | | 45 | 45 |
| max., minutes | 360 | 360 | 250 | 360 | 360 | 375 | | 375 | | 375 | | 375 | 375 |
| Heat of hydration | | | | | | | | | | | | | |
| 7 days, kJ/kg, max. | – | 300 | – | 275 | – | – | | 290 | | – | | 250 | – |
| 28 days, kJ/kg, max. | – | – | – | – | – | – | | – | | – | | 290 | – |
| Sulphate expansion | | | | | | | | | | | | | |
| 14 days, max, % | – | 0.050 | – | – | 0.035 | – | | – | | – | | – | 0.040 |

*[1] Air permeability test, minutes [2] Vicat test*
*[3] Lower values prevail in the U.S. when the optional heat of hydration or sum of $C_3S$ and $C_3A$ is specified.*
*Source: Canadian Standards Association and ASTM.*

Table 3.5. ANALYSES OF TYPICAL RAW MATERIALS.

| | Chalk | Clay | Lime-stone | Shale | Marl | Typical raw mix |
|---|---|---|---|---|---|---|
| $SiO_2$ | 1.14 | 60.48 | 2.16 | 55.67 | 16.86 | 14.30 |
| $Al_2O_3$* | 0.28 | 17.79 | 1.09 | 21.50 | 3.38 | 3.03 |
| $Fe_2O_3$ | 0.14 | 6.77 | 0.54 | 9.00 | 1.11 | 1.11 |
| CaO | 54.68 | 1.61 | 52.72 | 0.89 | 42.58 | 44.38 |
| MgO | 0.48 | 3.10 | 0.68 | 2.81 | 0.62 | 0.59 |
| S | 0.01 | n.d. | 0.03 | 0.30 | nil | nil |
| $SO_3$ | 0.07 | 0.21 | 0.02 | nil | 0.08 | 0.07 |
| L.O.I. | 43.04 | 6.65 | 42.39 | 4.65 | 34.66 | 35.86 |
| $K_2O$ | 0.04 | 2.61 | 0.26 | 4.56 | 0.66 | 0.52 |
| $Na_2O$ | 0.09 | 0.74 | 0.11 | 0.82 | 0.12 | 0.13 |
| | 99.97 | 99.96 | 100.00 | 100.20 | 100.07 | 99.99 |
| $CaCO_3$ | 97.6 | | 94.1 | | 76.0 | 79.3 |

**Includes also $P_2O_5$, $TiO_2$ and $Mn_2O_3$.*
*Source: Lea, 1970.*

hydrates slowly and can lead to unsound concrete. Problems involving limestones with excessive magnesia can sometimes be solved by drilling, sampling, and selective quarrying. Both core and rotary drilling and sampling techniques are employed to provide information about the composition and thickness of a deposit. Information obtained from exploration drilling and mapping is used as a basis for planning and developing methods of quarrying. In general, cement plant operators require a deposit with at least 50 years of readily accessible rock before they will consider it as a source of raw material.

Table 3.6. DISTRIBUTION OF CEMENT RAW MATERIALS, CANADA AND UNITED STATES, 1984.

| | Canada % | U.S. % |
|---|---|---|
| **Calcareous** | | |
| Limestone | 69.42 | 63.97 |
| Cement rock | 14.38 | 19.99 |
| Coral | – | 1.05 |
| Other | n.a. | 0.20 |
| **Argillaceous** | | |
| Clay | 0.05 | 4.64 |
| Shale | 3.73 | 2.62 |
| Other | n.a. | 0.10 |
| **Siliceous** | | |
| Sand & calcium silicate | 2.11 | 1.59 |
| Sandstone, quartzite, other | n.a. | 0.50 |
| **Ferrous** | | |
| Iron ore, pyrite, mill scale | 1.10 | 1.08 |
| **Other** | | |
| Gypsum & anhydrite | 4.39 | 3.26 |
| Blast furnace slag | 0.85 | 0.08 |
| Fly ash | – | 0.66 |
| Other | 3.97 | 0.26 |
| TOTAL | 100.00 | 100.00 |

Source: *Statistics Canada, 1984.*
*U.S. Bureau of Mines, 1985.*

## RAW MATERIAL EXTRACTION

Raw materials for cement manufacture are generally obtained by quarrying the rock. Depending on the nature of the materials, the limestone may be either blasted free or ripped using heavy machinery. Shales are generally loosely consolidated and can be readily ripped, while silica is obtained from loose sand deposits or from the crushing of sandstone. Silica and alumina are also obtained from the excavation and washing of clays.

Iron ore, mill scale, gypsum and anhydrite are generally purchased in the open market by cement manufacturers, as are other limestones necessary to bring the essential chemical components to the required levels.

## PROCESSING

The process of cement manufacture consists of the incorporation of the raw materials to form an homogeneous mixture, the burning of the mix in a kiln to form a clinker, and the grinding of the clinker to a fine powder, with the addition of a small proportion of gypsum. About 1.8 tonnes of raw materials are required to manufacture 1 tonne of finished cement; 1.7 tonnes are used to make clinker, and the remaining 0.1 tonne is added during the clinker–grinding process.

Raw material grinding takes place using either the wet process or the dry process. In Ontario, and in North America generally, the dry process is predominant in terms of clinker production capacity. Dry process plants accounted for approximately 70% of Canadian clinker capacity and over 80% of Canadian cement production in 1984. In the United States dry process plants were responsible for approximately 60% of clinker production in 1984.

Wet process plants vary depending on the nature of the raw materials. In the U.K. and other areas where chalks and marls are used as the raw materials, these rocks are broken up and combined in wash mills. These usually consist of circular pits lined with bricks or concrete, and containing gratings in the walls through which the raw materials can pass when reduced to a sufficiently fine condition. The chalk and clay are fed in the required proportions to the wash mill together with sufficient water to form a liquid of creamy consistency that is pumped to slurry tanks or basins.

If the raw materials are harder limestones and shales, the wash mill is inadequate to reduce the materials to the required fineness. This situation generally prevails in North America and is the case for Ontario cement producers. The raw materials in such cases are crushed and fed to ball mills, and water added in an amount to form a slurry. Clay, if it is used, is usually fed to the ball mill already dispersed in the water. The finished slurry usually does not contain more than a few percent of material retained on a 170 mesh, and its water content varies from 35% to 45% with different raw materials. The slurry is pumped to slurry tanks or basins and agitated to keep the mixture homogeneous. The proportion of lime in the mix is controlled by analysis and adjusted periodically as required. Final adjustment of composition is often obtained by blending the slurry from two basins, one of which is kept slightly high and one slightly low in lime. In some plants more elaborate blending systems are practised, using a number of slurry basins, blending tanks, and final storage tanks. The finished slurry is fed to the kiln.

Dry process plants are now the most common type of cement plant in Canada. In the dry process the raw materials are crushed, dried in rotary driers, proportioned, and then ground in ball mills to a fineness ranging from 75% to 90% passing 200 mesh. The ball mills are continuous in operation, receiving raw material at one end and discharging ground material at the other. They are often divided into two, three, or even four compartments containing balls of different size. Two mixes, one high and one low in lime, are often prepared and blended in the required proportions in a silo with vigorous air circulation. The dry powder is fed to the kiln.

At many new dry process plants, roller mills are replacing ball mills. In roller mills, the material is dried during pulverization using waste heat from the kiln, significantly improving energy efficiency.

Figure 3.3 illustrates the wet and dry processes for the manufacture of cement.

Burning is the most important operation in the manufacture of cement. The strength and other properties of cement depend on the quality of the clinker produced. Fuel consumption is a major expense and several technologies have been introduced to improve energy utilization in cement manufacture. Rotary kilns are the only type of kiln used in Canadian cement manufacture.

Rotary kilns are used for both wet and dry process cement manufacture. The kiln is a refractory lined cylindrical steel shell that rotates around an inclined axis. Blended dry mix or slurry enters the upper or feed end of the kiln and is conveyed by the slope and rotation to the firing or discharge end of the kiln. The variations in wet and dry process cement kilns are described below.

Wet process kilns employ chains in the upper part of the kiln to assist in the transfer of heat from the kiln gases to the raw materials. The slurry is dried in the upper part of the kiln and water driven off as steam and then, as it descends the kiln, the dried slurry undergoes a series of reactions, forming hard granular masses known as clinker in the most strongly heated part of the kiln. The clinker is discharged into air coolers, which may consist of a series of cylinders arranged around the periphery of the kiln; or onto a traveling or reciprocating grate cooler where air passes through the slowly moving bed of hot clinker. If a traveling or reciprocating grate cooling system is used, the heated air drawn from the coolers is recovered and used for the combustion of coal (if a coal–fired plant) or passed back to the upper stage of the kiln for drying of the slurry.

Wet process kilns are typically quite long, and may be up to 213 m in length and 7.6 m in diameter. The long length of the kiln improves the thermal efficiency of the kiln and enables the exit gas temperature to be reduced to 93°C or even lower.

Numerous methods are used to improve the fuel–efficiency of wet process plants. The water content of the slurry may be reduced by slurry filters, which are large rotating discs or drums covered with filter cloth. These devices reduce the water content to 20%–30% from 35%–45% in the filter cake. Heat transfer devices such as spiral vanes or guides in the back–end of the kiln or additional rotating cylinders may also be used. The slurry is passed through these devices before being fed to the kiln.

Dry process kilns are of two types: a short kiln with a preheater, and a long kiln similar to a wet process kiln, but somewhat shorter and differing in that the gas exit temperature is lowered to about 87°C. The temperature of the clinker discharged from the kiln is thereby reduced and some of the clinker heat is recovered and used to heat combustion air inside the kiln.

Energy conservation is a major theme in dry process cement manufacture. In Canada in 1984 the average energy consumption per tonne of cement was 4,931 MJ (4.7 million Btu). This contrasts with an average energy consumption of 6,714 MJ (6.4 million Btu) for U.S. cement producers. These data show substantial declines from the energy consumption recorded 10 years ago in

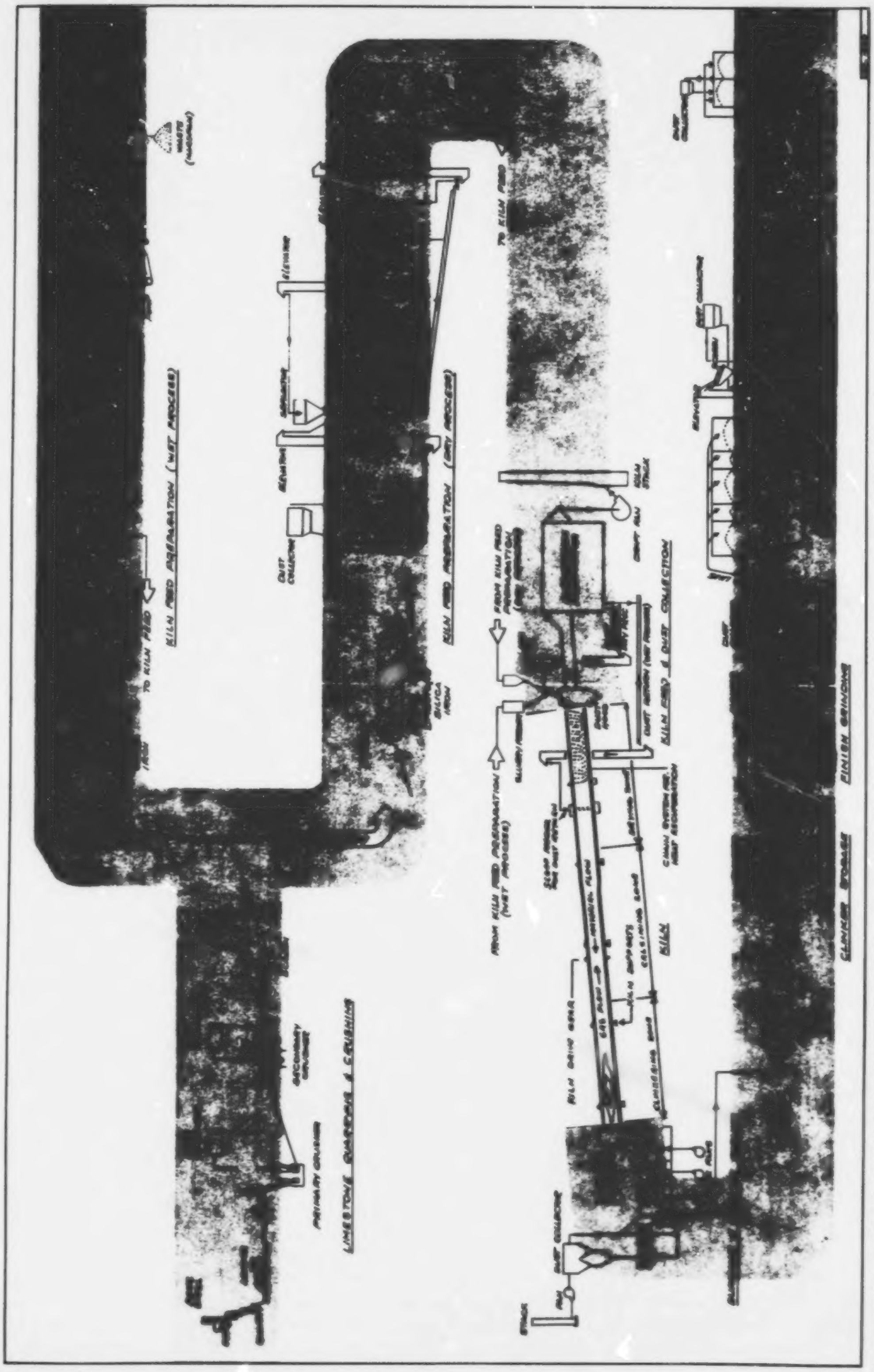

LIMESTONE QUARRYING & CRUSHING
PRIMARY CRUSHER
SECONDARY CRUSHER
KILN FEED PREPARATION (WET PROCESS)
KILN FEED PREPARATION (DRY PROCESS)
TO KILN FEED
DUST COLLECTOR
ELEVATOR
SEPARATOR
SILICA
IRON
FROM KILN FEED PREPARATION (WET PROCESS)
FROM KILN FEED PREPARATION (DRY PROCESS)
KILN DRIVE GEAR
GAS FLOW
MATERIAL FLOW
KILN SUPPORTS
CLINKERING ZONE
CALCINING ZONE
KILN
KILN FEED & DUST COLLECTION
KILN STACK
STACK
CLINKER STORAGE
FINISH GRINDING

Figure 3.3. (TOP) WET CEMENT PROCESS. (MIDDLE) DRY CEMENT PROCESS. (BOTTOM) FINAL GRINDING OF CLINKER. (Figure courtesy of Lafarge Canada Inc.)

both countries. Figure 3.4 illustrates changes in energy consumption in Ontario. Energy efficiency has been a major factor in the success of Ontario cement producers in penetrating the U.S. market.

The most popular method of energy conservation has been to use a preheater. The suspension preheater is the most common and is composed of a system of multistage cyclones and riser ducts in which the kiln feed is heated in suspension and partially calcined when it comes into contact with kiln exit gases. Some preheaters are equipped with pre–calciners that, by using kiln exit gases together with separate burners, achieve up to 95% calcination of raw material before it enters the kiln. Thus, the preheater–precalciner system permits the use of shorter kilns with less loss of heat. By the end of 1985 there were 59 suspension and 18 grate type preheaters in operation out of a total of 275 cement kilns in the United States. Canadian cement plants operated 9 preheaters on a total of 49 kilns in 1985.

The Lepol kiln is a variant of the preheater–precalciner system and uses a travelling chain grate enclosed by a casing which is installed in advance of the kiln. The raw materials are prepared in the form of small nodules by the addition of a small amount of water to the dry mix. The nodules are piled in a layer approximately 15 – 20 cm thick on the travelling grate which conveys them to the kiln. The hot waste gases from the kiln are sucked through the raw mix and the heat transferred. Exit gas temperatures can be reduced to as low as 49°C using this system in conjunction with a short kiln having a high exit–gas temperature.

Ontario cement plants employ gas, oil, and coal firing systems, with pulverized coal now being the preferred fuel. Several companies have also investigated the use of alternative fuels such as refuse, waste rubber and tires, electrical insulating oils, etc. The change in the distribution of fuel mix for cement production from 1980 through 1985 is shown in Figure 3.5 and Table 3.7. For Canada as a whole, the distribution of fuel mix was as follows:

| | 1974 | 1985 |
|---|---|---|
| natural gas | 49.5% | 37.8% |
| petroleum products | 39.7% | 6.9% |
| coal and coke | 10.8% | 55.4% |

Source: Canadian Minerals Yearbook, Cement, 1986.

A similar change in fuel mix distribution has taken place in the United States cement industry. Coal and coke accounted for 92% of fuel consumption on an energy content basis in 1983, and 95% in 1985. In 1972 coal and coke represented less than 39% of the energy requirements of U.S. cement plants. Figure 3.5 and Table 3.8 illustrate the distribution of energy sources for Ontario and U.S. cement producers in 1984 and 1985.

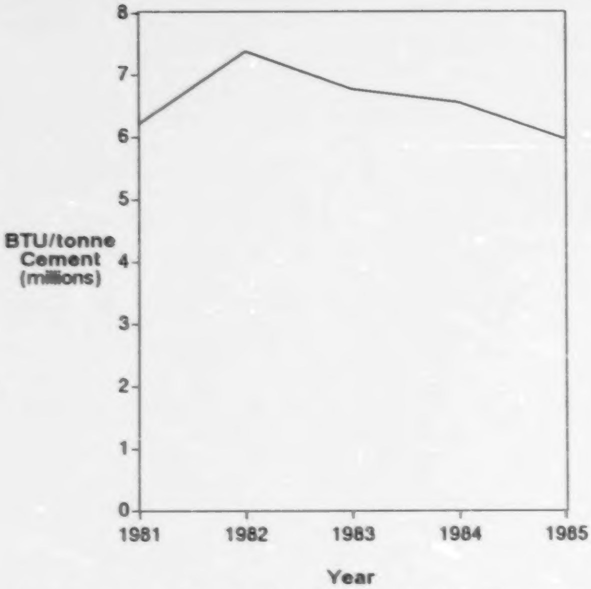


**Figure 3.4.** ENERGY ANALYSIS; ONTARIO CEMENT PRODUCERS.

Wet process plants are generally more energy intensive than dry process plants and typically require approximately 4% more energy per tonne of clinker. However, dry process plants equipped with suspension preheater systems will require only 70% of the energy required by a wet process plant. Dry process plants equipped with grate–type preheater systems require approximately 90% of the energy per tonne of clinker that wet process plants use. Data available for energy use in the U.S. cement industry indicate the following for 1985:

- wet process plants 6476 MJ/tonne clinker
- dry process plants 4857 MJ/tonne clinker
    - no preheater 6592 MJ/tonne clinker
    - suspension preheater 4513 MJ/tonne
    - grate type preheater 6244 MJ/tonne

These data are 26% less than 1972 for wet process plants and 17% less than 1972 for dry process plants in terms of energy consumption per tonne of clinker produced.

Finish grinding takes place in ball mills which are similar in design to the raw mills. Clinker from storage or directly from the coolers is fed to the mills, along with anhydrite or gypsum in amounts up to 5%. The material is ground to a particle size of approximately 10 microns. The fineness of the material is generally given in terms of the specific surface area in square metres per kilogram measured by the air permeability test, and is referred to as the Blaine number. Most cements are finished to a Blaine number ranging from 4200 to 4500. The fineness

**Table 3.7. ENERGY ANALYSIS. ONTARIO CEMENT PRODUCERS.**

| Energy source | Energy consumption ($) | | | | | |
|---|---|---|---|---|---|---|
| | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 |
| Coal and coke | 12,241,928 | 18,688,449 | 20,376,991 | 19,286,487 | 23,326,575 | 31,166,125 |
| Natural gas | 10,231,159 | 10,848,681 | 9,088,615 | 7,544,562 | 8,451,778 | 8,799,205 |
| Light fuel oil | 217,106 | 374,858 | 313,392 | 296,170 | 524,627 | 225,671 |
| Heavy fuel oil | 7,522,686 | 6,333,950 | 3,067,768 | 2,768,052 | 2,938,060 | 4,410,979 |
| Diesel oil | 618,020 | 939,004 | 874,241 | 582,423 | 631,314 | 675,875 |
| Electricity | 12,343,839 | 14,033,355 | 13,798,068 | 14,438,896 | 17,333,984 | 20,703,566 |

*Source: "Ontario Mineral Score", Ontario Ministry of Northern Development and Mines, 1986*

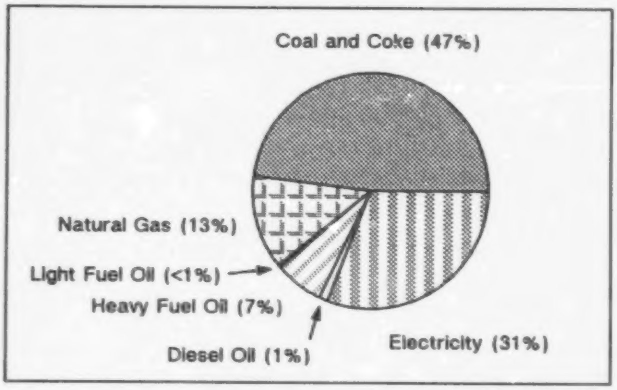


**Figure 3.5. ENERGY COST/TONNE OF CEMENT 1985.** *Source: "Ontario Mineral Score", Ontario Ministry of Northern Development and Mines, 1986.*

**Table 3.8. ONTARIO–UNITED STATES ENERGY CONSUMPTION PER TONNE CEMENT PRODUCED, 1984–1985.**

| 1984 | Ontario | U.S. |
|---|---|---|
| Coal (t) | 0.1121 | 0.1814 |
| Natural gas ($m^3$) | 0.0149 | 5.9280 |
| Fuel oils (1) | 4.1312 | 1.7428 |
| LPG (1) | 0.0470 | n.a. |
| Electricity (kWh) | 136.5 | 154.6 |
| **1985** | | |
| Coal (t) | 0.1414 | 0.1555 |
| Natural gas ($m^3$) | 0.0144 | 4.4532 |
| Fuel oils (1) | 4.5192 | 1.7728 |
| LPG (1) | 0.0728 | n.a. |
| Electricity (kWh) | 154.3 | 152.3 |

*Source: "Ontario Mineral Score", Ontario Ministry of Northern Development and Mines, 1986*
*U.S. Bureau of Mines*

is controlled with air separators in closed circuit with the grinding mills. When the proper fineness has been achieved the cement is passed to storage silos and/or to the pack house for shipment in bulk by rail car, truck, and boat, or in bags.

Electrical energy requirements for grinding (raw and finish) averaged approximately 138 kilowatt hours per ton, or about 1388 MJ per tonne of finished cement in the U.S. in 1985. Ontario cement plants consumed approximately 154 kWh per tonne of cement production in 1985 (Table 3.8).

Dust control is of major concern to the cement industry. In wet process plants the dust at the kiln exit varies up to about 5% of the clinker output and in dry process plants it can rise as high as 15%. Dust is also generated during the finish grinding process.

Electrostatic precipitators, cyclone separators, scrubbing towers and bag filters are used to trap the dust, which is usually returned to the kiln. The dust is relatively rich in the more volatile constituents of the charge, and this can cause problems with alkali buildup in the precipitators if the limestone is high in potassium, sodium, and chlorine. For this reason,most electrostatic precipitators are equipped with by–pass features to enable regulation of deleterious alkali buildup. Dust from the finish mills is generally captured by means of bag filters and cyclone towers and charged back to the mills.

## CEMENT USES

By itself, cement has very little use. However, when combined with water, sand, and suitable aggregate material such as crushed stone or slag, in proper proportions it acts as a binder, cementing the materials together as concrete; one of the most versatile building materials known. Concrete finds use in all forms of construction and in the manufacture of concrete products such as pipe, building blocks, pre–stressed bridge piers and sections, etc. Cement can also be used in the manufacture of concrete (calcite) bricks which are between 20% to 30% less expensive than clay bricks. They have been improved in quality and colour to such an extent in recent years that they are very difficult to distinguish from the clay product. Concrete bricks enjoy strong demand in Ontario, accounting for about 25% of the total brick market in 1984. They are produced by several of the building materials subsidiaries of the cement producers such as Canada Building Materials (St. Marys Cement), Primeau

Argo Block (Lake Ontario Cement), and Richvale Building Materials (Lafarge Canada).

Pre-stressed and pre-cast concrete structures are enjoying increased demand. Such structures offer engineers and contractors lower cost alternatives for engineering construction such as bridges and highway piers and for commercial building construction. An interesting new development is the use of pre-cast panels faced with thin veneers of building stones such as limestone or granite. The combination of the materials allows the architect to design a very attractive building at competitive construction costs. An example of this technique is the recently completed Carleton County courthouse in Ottawa, which is faced with limestone.

## TECHNOLOGY

Technical developments related to the use of cement and concrete include the following:

- The development of fibre-reinforced concretes using plastic, glass and ceramic-based fibres for reinforcements. The fibres are incorporated into the concrete to prevent crack propagation and increase the impact resistance of the concrete.
- The development of synthetic chemical additives to impart increased chemical resistance, crack resistance, impact resistance and workability.
- The development of high-shear processing techniques, together with rolling or pressing to remove pores from low- water calcium aluminate cement pastes. The pastes contain from 5% to 7% organic polymers to improve workability. The resulting paste is called macro-defect-free or MDF cement and, on hardening, has a strength similar to that of aluminium and much lower permeability than ordinary portland cement.
- The development of new cementitous aggregates such as fly ash and microscopic silica particles. The minerals help to fill the pores in the concrete and improve the bonding properties of the cement, resulting in greater strength and reduced permeability.
- The development of very high compressive strength concretes. Typical concretes have compressive strengths of approximately 34 MPa (5,000 psi). Concretes with compressive strengths of 69 to 103 MPa (10,000 to 15,000 psi) are becoming common, and concretes with strengths of at least 310 MPa (45,000 psi) have been developed. Even higher strengths should be possible. Higher compressive strength concretes will permit the use of smaller columns in high rise buildings with consequent savings in space and materials.
- The development of new non-calcareous concretes such as sulphur concretes may negatively affect the market for portland cement. Sulphur concrete, for example, offers superior corrosion resistance in acidic environments and can be recycled by remelting and recasting without loss of the mechanical properties.
- Use of portland cement as an anti-stripping agent in asphalt mixes may increase the consumption of cement and offer a lower cost alternative to sulphur in this application.
- New cement plant technologies include the use of compressed air cannons to remove material build-up in cement kiln pre-heaters, and the development of high efficiency air separators in the grinding circuit.
- Portland cement could be used as a sulphur removal agent in fossil fuel-fired power plants. The cement would be used in place of limestone, lime or other basic material, and could eventually prove to be a cheaper material to use.

# Lime, Chemical and Metallurgical Stone

Limestone is one of the most widely used raw materials in industry. Starting with crude crushed stone, limestone is used to produce lime which is consumed in almost every branch of industry as a chemical and metallurgical intermediate, fluxing agent, additive, soil conditioner and stabilizer, building material, and a host of other uses.

## LIME

Lime is the product of heating calcium and/or magnesium carbonate rocks to the dissociation temperature of the carbonates, and holding the material at that temperature for a sufficient period to release carbon dioxide. The process is referred to as calcination. The term "lime" should only be applied to calcined limestone and dolomitic materials, and their secondary products, hydrated and slaked lime. Hydrated lime is the product of mixing calcined lime, quicklime, with water; drying the resulting product, and (possibly) regrinding. Slaked lime is the product of mixing quicklime with excess water to form a slurry.

The principal Canadian markets for lime are the steel industry, the pulp and paper industry, and the mining industry. Lime is also used in water and sewage treatment, sugar refineries, glass and chemical production, fertilizer production, tanneries and in agriculture, road and soil stabilization, construction products, and other uses.

Lime is of two primary types. High calcium lime is produced by the calcination of high calcium limestone, and is by far the most important form of lime. Dolomitic lime is produced by the calcination of dolostone, $CaCO_3 \cdot MgCO_3$, and is more restricted in use than high calcium lime. Dead-burned dolomite is a special form of dolomitic lime that is produced by sintering a mixture of dolostone and 5%–10% iron oxide (mill scale) at high temperatures (1650°C) in the presence of low ash coal. The resulting product possesses good refractory properties and is employed as a lining in steelmaking and other high temperature industrial furnaces.

## LIME MANUFACTURE

The manufacture of lime is accomplished by the calcination of crushed limestone or dolostone. Because of variations in limestone chemistry, crystal form, and other physical properties, no two limestones will produce identical limes; even when calcined under identical conditions in identical kilns (see Figure 3.6). As a result, most lime material specifications are quite general and liberal in their provisions.

### CALCINATION

Lime manufacture begins in the calcination, a thermal process resulting in the release of carbon dioxide gas from limestone and dolostone. It is a reversible reaction and can be represented as follows:

$$CaCO_3 \text{ (limestone)} + \text{heat} \Leftrightarrow CaO \text{ (h.c. quicklime)} + CO_2$$

$$CaCO_3.MgCO_3 \text{ (dolostone)} + \text{heat} \Leftrightarrow CaO.MgO \text{ (dol. lime)} + 2\ CO_2$$

The three essential factors in the reaction are:

1. The stone must be heated to the dissociation temperature of the carbonates.
2. This minimum temperature (but in practice a higher temperature) must be maintained for a certain duration.
3. The carbon dioxide gas that is evolved must be removed.

High calcium limestones have a dissociation temperature approximately that of pure calcite, which is 898°C at 1 atmosphere pressure (760 mm) for a 100% $CO_2$ atmosphere. Pure magnesium carbonate has a disso-

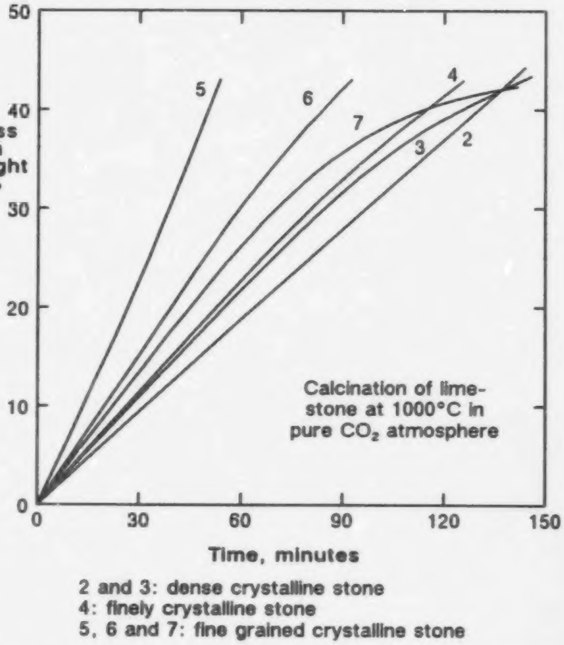


**Figure 3.6. VARIABLE RATES OF DISSOCIATION FOR DIFFERENT SPECIES OF LIMESTONE.** *Source Boynton, 1980.*

ciation temperature in the range 402 to 480°C. The proportions of calcium and magnesium carbonates in a particular dolostone will affect the dissociation temperature. A good "average" value for dissociation would be 725°C at 760 mm pressure and 100% $CO_2$ atmosphere, with the $CaCO_3$ component dissociating at the higher temperature for calcite, resulting in a dual-stage decomposition.

As a consequence, the MgO component in dolomitic lime is necessarily hard-burned before the CaO is formed. This problem can be alleviated by cooling the quicklime immediately after the $CaCO_3$ is calcined and by calcining at minimum and constant temperatures, but for a longer duration.

Critical parameters in the successful calcination of limestone and dolostone are the following:

- Regulation of $CO_2$ partial pressure. It is essential to have rapid and continuous evolution of $CO_2$ to reduce the dissociation temperature. The relationships between temperature, pressure, and $CO_2$ concentration are illustrated in Figure 3.7.
- Stone size. Moderate kiln stone sizes (1 1/2 in. – 8 in. diameter) are generally required to permit rapid and thorough heating. Stone should also be relatively uniform in size with a maximum size gradation of 1:3 to promote even calcination. It is desirable that stones have relatively uniform thickness as well as length and width as the rate of calcination is directly proportional to the square of the thickness of the stone.

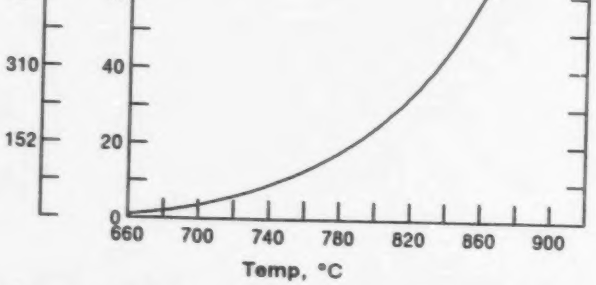


**Figure 3.7. INFLUENCE OF $CO_2$ CONCENTRATION AND PRESSURE ON DISSOCIATION TEMPERATURE OF $CaCO_3$.** *Source Boynton, 1980.*

- Porosity and density of the stone. High porosity is associated with low shrinkage and high lime reactivity. Dense, fine-crystalline stones tend to hard-burn and produce a less reactive lime with more core (uncalcined material).
- Rate of heating and final temperature. Generally, gradual preheating and a gradual increase in calcination temperature up to the point of complete dissociation results in the most reactive lime.

The relationships between stone size (surface area), calcination temperature, and duration of calcination are illustrated in Figure 3.8.

The heat consumed during dissociation is determined by the specific heat of the material. The theoretical heat requirements for dissociation of $CO_2$ are:

| | |
|---|---|
| high calcium limestone: | 1,696 MJ/tonne<br>(1,458,814 Btu/ton) |
| dolostone: | 1,450 MJ/tonne<br>(1,247,103 Btu/ton) |

To this heat requirement must be added the heat required for the retention of the dissociation temperature. These values are approximately 2,900 to 3,500 MJ/tonne (2.5 to 3.0 million Btu/ton) for high calcium lime and 3,025 to 3,220 MJ/tonne (2.60 to 2.77 million Btu/ton) for dolomitic lime. The total heat requirements are therefore:

| | |
|---|---|
| high calcium quicklime: | 4,605 to 5,190 MJ/tonne<br>(3.96 to 4.46 million Btu/ton) |
| dolomitic quicklime: | 4,475 to 4,675 MJ/tonne<br>(3.85 to 4.02 million Btu/ton) |

## LIME KILNS

Figure 3.9 provides a simplified flow sheet for an integrated lime operation. The key component of a lime plant is the kiln, though few of the many types that have been developed over the past 100 years have proven to be commercial successes. All of these are variants of vertical and rotary kilns. The principal types of lime kilns are detailed below.

### VERTICAL KILNS

All modern vertical kilns are divided into four principal zones: (1) stone storage; (2) preheating zone; (3) calcining zone; (4) cooling and discharge zone. Differences in the design of these zones constitute the "art" of vertical kiln design.

Traditional vertical kilns are of the mixed feed design, and the gas-fired cross-flow and centre burner type. Mixed feed kilns are fired with a low-ash coal or coke which is fed to the kiln in direct association with the kiln stone. The resulting lime is generally of inferior quality due to sulphur contamination, but the kiln offers very high thermal efficiency and generates substantial amounts of $CO_2$ gas, which can be recovered and used in

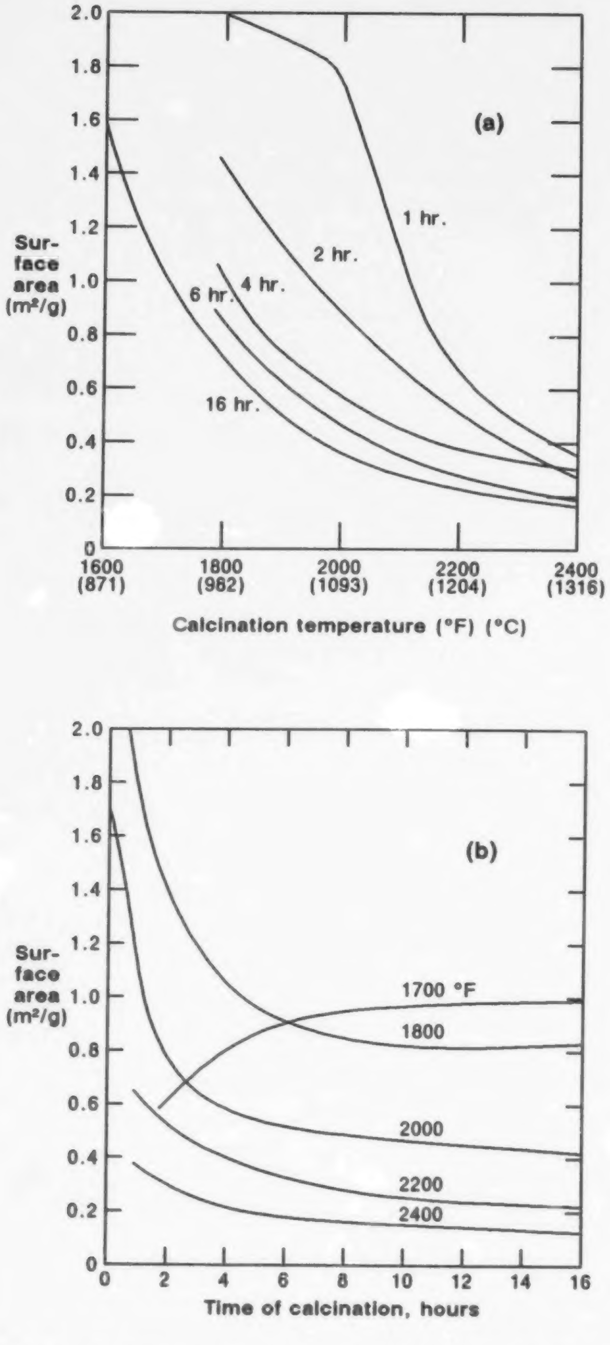


**Figure 3.8.** (a) RELATION OF SURFACE AREA TO CALCINATION TEMPERATURE. (b) RELATION OF SURFACE AREA TO DURATION OF CALCINATION. *Source Boynton, 1980.*

chemical processes such as soda ash manufacture and in sugar refining.

The centre burner kiln offers greatly increased production capacity and fuel efficiency over older vertical kiln designs. The Azbe kiln uses recirculation of the hot exit gases for calcination. The cross–flow kiln passes the gases at right angles through the stone. Union Carbide has developed a variant of the cross–flow kiln in which burner beams are used at two levels to provide more uniform calcining. The Union Carbide design is quite popular in the United States.

The latest versions of the vertical shaft kiln are of three types: parallel–flow or Maerz kiln, double–inclined kiln, and annular or ring kiln. These kiln designs offer very high thermal efficiency and yield a more reactive and pure lime (1–1.5% unburnt core) with lower levels of sulphur content than mixed feed kilns. Table 3.9 provides a comparison of experience with various vertical kiln designs.

## ROTARY KILNS

The rotary kiln is by far the most popular design in North America. Despite its higher capital cost and lower thermal efficiency in comparison to modern vertical shaft kilns, the rotary kiln is preferred due to its ability to fire any fuel and its ability to handle a wide range of stone sizes. These factors enable rotary kiln operators to switch fuel sources relatively easily as conditions warrant,and to reduce the build–up of unusable stone fines. The modern rotary kiln is generally fired with pulverized coal, though most are also equipped with stand–by fuel facilities to fire oil and/or natural gas. Current designs incorporate numerous energy conserving devices such as preheaters, internal heat exchangers, and lime coolers, etc., many of which are common to cement plant kilns. Modern rotary kilns tend to have a low length:diameter ratio as opposed to the more traditional long rotary kiln. The short rotary kiln is generally more thermally efficient than the long rotary kiln. Energy conserving devices used in rotary kilns are detailed below:

## PREHEATERS

Preheaters offer the most potential for improving thermal efficiency in lime manufacture. The most popular forms of preheaters are the following:

- travelling grate type (AC–Lepol)

  this features a travelling grate which acts as a preheater and pre–calciner. The system can handle a very broad range of stone sizes from 4 mesh to 5 cm and offers good thermal efficiency of approximately 5,580 MJ/tonne (4.8 million Btu/ton).

- shaft preheaters

  there are several varieties. The best performance in retrofit applications is with short rotary kilns (31 m to 53 m) of approximately 1:10 diameter:length. Traditional long rotary kilns of 76 m to 136 m have

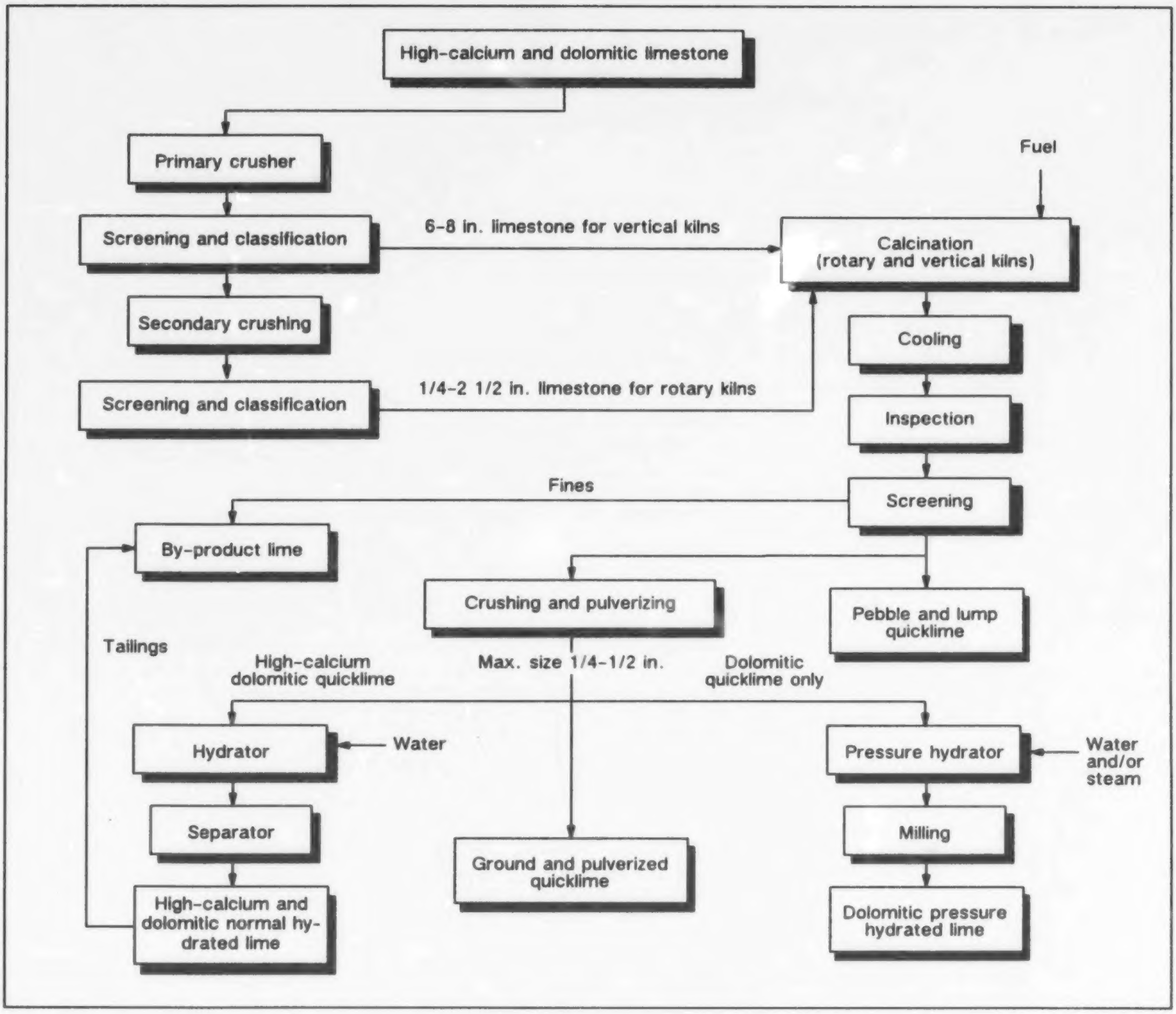

High-calcium and dolomitic limestone
Primary crusher
Fuel
Screening and classification
6-8 in. limestone for vertical kilns
Calcination (rotary and vertical kilns)
Secondary crushing
Cooling
Screening and classification
1/4-2 1/2 in. limestone for rotary kilns
Inspection
Fines
Screening
By-product lime
Crushing and pulverizing
Pebble and lump quicklime
Tailings
High-calcium dolomitic quicklime
Max. size 1/4-1/2 in.
Dolomitic quicklime only
Hydrator
Water
Pressure hydrator
Water and/or steam
Separator
Milling
Ground and pulverized quicklime
High-calcium and dolomitic normal hydrated lime
Dolomitic pressure hydrated lime

**Figure 3.9. SIMPLIFIED FLOW SHEET OF INTEGRATED LIME OPERATION.** *Source Boynton, 1980.*

been less successful. The two most popular types are by KVS, which makes standard shaft, rectangular, and polygon shaped units for kilns up to 900 tonnes/day capacity; and by Parsons and Kraus– Maffei. Thermal efficiencies for both designs are in the 4,885 to 5,580 MJ/tonne (4.2 to 4.8 million Btu/ton) range.

## KILN INTERNALS

Internal kiln design features promoting thermal efficiency include heat exchanger cross section design enhancements such as trefoils, dams and lifters, chains, etc. The essential feature of all of these kiln internals is that they promote greater heat exchange with the stone and more even heating by constantly exposing all parts of the stone to the hot gases.

## COOLERS

Coolers provide for heat recovery and the cooling of the lime. There are several types:

- Contact or Niems coolers
- Planetary coolers or satellite coolers

Table 3.9. COMPARISON OF SPECIFICATIONS OF SHAFT KILNS.

| | Regular | Union Carbide | Cross Flow | Double Inclined | Annular | Parallel Flow Regenerative |
|---|---|---|---|---|---|---|
| Shaft | Round | Rectangular | Rectangular | Rectangular | Round | Round |
| Cross section area ($ft^2$) | 43-323 | | 42 | 56 | 99-315 | 25-172 |
| Capacity (STPD) | 50-500 | 150-600 | 200 | 120-175 | 100-500 | 100-600 |
| Capacity (MTPD) | 45-454 | 136-544 | 181 | 109-159 | 91-454 | 91-544 |
| Feed size | 2-1/2"-8" | 1"-7" | 3/4"-3" | 1/2" to 2-1/2" | 3/4"-5" | 3/4"-7" |
| Fuel | Coke, oil, gas | Oil, gas | Oil, gas | Coke, oil, gas | Oil, gas, Pulverized coal* | Oil, gas, Pulverized coal* |
| Fuel rate ($10^6$ Btu gross per short ton) | 3.38 to 4.50 | 4.9 to 5.2 | 4.0 to 4.4 | 3.78 to 4.18 | 3.78 to 4.18 | 3.38 to 3.78 |
| Power (kwh/MT) | 2.5-8 | 10-25 | 20-30 | 16-26 | 10-30 | 20-25 |

**Pilot installations in operation since 1981*

*Source: Schwarzkopf, 1981.*

- Rotary coolers
- Grate coolers

The most effective system for both heat recovery and lime cooling appears to be the contact cooler. The other types of cooler are less effective in heat recovery but approximately equal to the contact cooler in cooling performance.

Control of kiln stone feed size is critical to successful operation of rotary kilns. The maximum stone size is generally 2 in., although some operators use 2 1/2 in. stone. The minimum size is generally 1/4 in. or 3/8 in. Most plants operate with stone sizes in the range of 3/8 in. to 7/8 in.; 7/8 in. to 1 5/8 in.; 1 in. to 2 in.; and so on. Plants with multiple kilns may calcine two to four different gradations of stone to minimize the production of unusable stone fines.

Two other developments of note related to rotary kiln operation are the development of suspension preheater and flash calcining systems for lime kiln fines and limestone spalls; and the Maerz FK calcining method for limestone fines. The latter method uses a suspension preheater but not the flash calciner. These technologies, which have been adopted from the cement industry, allow lime producers to successfully calcine limestone fines and dust. The result is a significant increase in the size range of stone which can be converted into salable product, rather than stored as waste material or sold at very low prices. Both systems are also very thermally efficient.

## OTHER KILN TYPES

Two other kilns used in North America are the Fluo-Solids kiln and the Calcimatic kiln. The Fluo-Solids kiln successfully calcines very small stone of 8-65 mesh at high energy efficiencies. The operation of the kiln is based on the fluidized bed principle and requires very precise control. The kiln produces a very reactive lime with almost no core, and is most successful with soft limestones or heavily crystalline stone that thermally decrepitates. The Calcimatic kiln features a large diameter circular refractory hearth that can be operated at various speeds up to 200 rpm; most units operate in the 27 to 85 rpm range. The hearth is divided into heating zones, and extensive instrumentation is used for precise temperature control. The kiln can successfully calcine a wide range of stone types and sizes, varying from 1/4 in. to 4 in., with a maximum recommended gradation of 1:4. There is one Calcimatic unit in operation in Ontario at BeachviLime Ltd. in Beachville, Ont. (site A-3 in the Aylmer District chapter, Volume III).

## FORMS OF LIME

Quicklime is commercially available in the following forms:

1. Lump.

   Sizes range from 2 1/2 in. to 12 in., but usually a more restricted size range such as 3 in. x 6 in., 4 in.x 8 in., etc. These sizes are derived exclusively from vertical kilns.

2. Pebble.

   Sizes range from 1/4 in. to 2 1/2 in., but actual size distribution is more precise, such as 1/4 in. x 1/2 in., 1/2 in. x 1 in., etc. The product is available from both rotary and vertical kilns and the Calcimatic kiln.

3. Ground.

   Typical size range is 100% passing 8 mesh and 2%-4% passing 100 mesh. It is a secondary product resulting from the screening of fines or grinding and classifying coarser sizes.

4. Pulverized.

   Typical size range is 100% passing 20 mesh and 85%- 95% passing 100 mesh. It is produced by pulverization and classification of larger size material.

5. Briquettes (pelletized).

These are produced by compressing quicklime fines in special moulding equipment, to about 1 in. The volume of production is quite small.

## LIME HYDRATION

Lime hydration refers to the addition of water to quicklime whereby approximately stoichiometric amounts of water and lime react to form a chemically combined dry hydrate. It contains less than 1% free moisture and is handled as a dry powder. If excess water is added slaking is said to take place, with the formation of a lime slurry. This product is handled as a liquid. The hydration process is strongly exothermic. This heat may be captured for use in the hydration process or used for other processes, or more usually is wasted. High calcium quicklime hydrates much more readily than dolomitic lime. Special procedures and equipment are required to economically hydrate dolomitic lime. The rate of hydration is dependent upon the purity of the lime, the MgO content, the size of the starting lime particles (smaller is faster), the temperature of the water, the amount of water, degree of agitation, and extent air–slaked lime is used.

### SLAKING

Lime slaking may take place in either a batch or continuous mode. Batch slaking has largely been superceded by the continuous process. Paste slaking is the predominant method as it reduces the detention time by recovering some of the heat of hydration to increase the water temperature. The paste slaker also yields a more concentrated hydrate. Only large volume users such as pulp and paper mills employ slaking equipment today.

### DRY HYDRATION

Hydration plants also operate in batch and continuous modes, the latter type predominating. All hydrate production takes place in closed–circuit systems to prevent recarburation. Plant layout and equipment selection varies widely. The hydrated product is generally ground in a ball mill to improve the plasticity of the product. The most significant factors affecting hydrating plant design are:

- porosity and slaking rate of the quicklime
- chemical purity of the quicklime
- physical size and gradation of the quicklime
- temperature of the hydration water
- particle size requirement of the hydrate

## LIME SPECIFICATIONS

Specifications for lime are quite diverse due to the variations in the starting material. The ASTM has developed a series of specifications for both quicklime and hydrated lime for use in a wide range of applications. These specifications are summarized in Table 3.10. Canadian specifications for quicklime and hydrated lime generally follow the prescriptions of the ASTM.

## USES

### LIME

Lime is used in an extremely diverse range of applications. In industry it is the second largest volume basic chemical, next to sulphuric acid. It is used for neutralization, coagulation, causticization, dehydration, hydrolyzation, and absorption; in building construction as a cementitious material and as a plasticizer; in agriculture to supply calcium and magnesium as plant nutrients and for neutralization of acid soils; in highway construction for soil stabilization and as an anti–stripping agent in asphalt. High calcium and dolomitic lime may be used interchangeably for many of the listed applications. For certain applications, however, there are general preferences for one type over the other, and for some of these only one type of lime can be used. Similarly, both quicklime and hydrated lime may be used interchangeably for some applications. The selection will depend on the volume requirements and storage facilities as quicklime is the more reactive material and costs less per tonne. In other applications only quicklime or hydrated lime may be specified. A brief description of the uses of lime is provided in the following sections.

### IRON AND STEEL

Lime is used as a basic fluxing agent in iron and steelmaking processes. It is used in iron making in the manufacture of sinter and in the production of self–fluxing sinters and iron agglomerates (pellets). In steelmaking it is used as a flux to assist in the removal of phosphorus, silica, and sulphur. The most important steelmaking processes using lime are the basic oxygen furnace (BOF) and the electric arc furnace (EAF), and their variants. The use of lime, as opposed to limestone, in the basic open hearth furnace is limited and is rapidly declining as these furnaces are being phased out in favour of the BOF and EAF.

Both high calcium and dolomitic lime are used in BOFs, with dolomitic lime accounting for 20% to 30% of the total lime charge in most BOFs. Some BOFs use up to 50% dolomitic lime in the fluxing charge. Typical size specifications for lime call for lump or pebble material. However, those steel plants using the more modern LD–AC or Q–BOP BOF processes tend to prefer 200 mesh and 150 mesh material as it is injected into the melt via lances. Quicklime accounts for most lime consumption, although hydrated lime may be used as a heat insulator in the ladle refining process, especially if calcium wire is used as the flux. Dead–burned dolomite is used as a refractory material to protect the basic lining of open hearth furnaces and of electric furnaces.

**Table 3.10. ASTM LIME SPECIFICATIONS FOR QUICKLIME, HYDRATED LIME, AND LIMESTONE FOR CHEMICAL USES.**

| SPECIFICATION C911-87 | | | Chemical Requirements, % | | | | | | | | | | Physical Requirements | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | Dry Sieve | Wet Sieve | | |
| Use | ASTM Specification[1] | Approved Types of Lime or Stone | CaO min | CaO,+ MgO min | $SiO_2$+ $Fe_2O_3$,+ $Al_2O_3$, max | MgO, max | $CO_2$, max | $SiO_2$+ Insoluble matter, max | $Al_2O_3$+ $Fe_2O_3$, max | Available CaO, min | $Fe_2O_3$, max | Chemical Other | % -12 mesh min | % -30 mesh min | % -200 mesh min | % -325 mesh min |
| Cooking rags | C 45 | CH | - | - | - | - | - | - | - | 64.3[3] | - | - | - | - | - | - |
| Cooking rags | C 45 | CQ | - | - | - | - | - | - | - | 90.0[3] | - | - | - | - | - | - |
| Sulfite pulp | C 46 | CQ,MQ | - | 95.0[2] | 3.0[2] | - | - | - | - | - | - | - | - | - | - | - |
| Sulfite pulp | C 46 | CL,ML | - | 95.0[2] | 3.0[2] | - | - | - | - | - | - | - | - | - | - | - |
| Silica brick | C 49 | CH | 90[2] | - | - | 2.5[2] | 2.5 | 3.0[2] | 1.5[2] | - | - | Free CaO $\leq$1.5 | - | 99 | 95 | - |
| Silica brick | C 49 | CQ | 90[2] | - | - | 2.5[2] | 2.5 | 3.0[2] | 1.5[2] | - | - | | - | - | - | - |
| Water softening | C53 | CQ | - | - | - | - | - | - | - | 90 | - | - | - | - | - | - |
| Water softening | C53 | CH | - | - | - | - | - | - | - | 68.1 | - | - | - | - | - | - |
| Other water treatment uses | C 53 | CQ,DQ,<br>MQ | - | 93.0 | - | - | - | - | - | - | - | - | - | - | - | - |
| Other water treatment uses | C 53 | CH,DH<br>MH | - | 93.0[2] | - | - | - | - | - | - | - | - | - | - | - | - |
| Carbide | C 258 | CQ | 92[2] | - | - | 1.75[2] | 4.0 | 2.0[2] | 1.0[2] | - | 0.5 | P $\leq$0.02[2]<br>S 0.2[2] | - | - | - | - |
| Grease | C 259 | CH | - | - | - | 1.5 | - | 1.0 | - | - | 0.5 | available $Ca(OH)_2$ $\geq$90 | - | - | 98 | 95 |
| Calcium silicate product | C 415 | CH | 90[2] | - | - | 1.3[2] | 2.5 | 3.0[2] | 1.5[2] | - | - | - | - | 99 | 95 | - |
| Calcium silicate product | C415 | CQ | 90[2] | - | - | 1.3[2] | 2.5 | 3.0[2] | 1.5[2] | - | - | - | 99 | - | - | - |
| Hypochlorite bleach | C 433 | CH | - | - | - | - | - | - | - | 68 | 0.3[2] | - | - | - | - | - |
| Hypochlorite bleach | C 433 | CQ | - | - | - | - | - | - | - | 90 | - | - | - | - | - | - |
| Industrial waste treatment | C 826 | CH<br>DH<br>MH | - | 95.0[2] | - | - | 5.0 | - | - | - | - | BF > 0.72[4]<br>BF > 0.81[4]<br>BF > 0.74[4] | - | - | 85 | - |
| Industrial waste treatment | C 826 | BH | - | 90.0[2] | - | - | - | - | - | - | - | - | - | - | 70 | - |
| Industrial waste treatment | C826 | CQ<br>DQ<br>MQ | - | 90.0 | - | - | - | - | - | - | - | BF > 0.93[4]<br>BF > 1.06[4]<br>BF > 0.93[4] | - | - | 85[5] | - |
| Industrial waste treatment | C826 | CL<br>DL<br>ML | - | 90[2] | - | - | - | - | - | - | - | BF > 0.45[4]<br>BF > 0.56[4]<br>BF > 0.48[4] | - | - | - | - |

[1] *These designations refer to the following ASTM Methods.*
*C 45 Specification for Quicklime and Hydrated Lime for Cooking of Rags in Paper Manufacture*
*C 46 Specification for Quicklime and Limestone for Sulfite Brick Manufacture*
*C 49 Specification for Quicklime and Hydrated Lime for Silica Brick Manufacture*
*C 53 Specification for Quicklime and Hydrated Lime for Water Treatment*
*C 258 Specification for Quicklime for Calcium Carbide Manufacture*
*C 259 Specification for Hydrated Lime for Grease Manufacture*
*C 415 Specification for Quicklime and Hydrated Lime for Calcium Silicate Products*
*C 433 Specification for Quicklime and Hydrated Lime for Hypochlorite Bleach Manufacture*
*C 826 Specification for Lime and Limestone Products for Industrial Waste Treatment*

[2] *On a nonvolatile basis.*

[3] *Standard composition.*

[4] *BF means Basicity Factor.*

[5] *Slaked basis.*

*Limestone, high-calcium - CL*
*Limestone, dolomitic - DL*
*Limestone, magnesian - ML*
*Quicklime, high-calcium - CQ*
*Quicklime, dolomitic - DQ*
*Quicklime, magnesian - MQ*
*Hydrated lime, high-calcium - CH*
*Hydrated lime, dolomitic - DH*
*Hydrated lime, magnesian - MH*
*Hydrated lime, by-product - BH*

Table 3.10. CONTINUED.

QUICKLIME FOR STRUCTURAL PURPOSES
SPECIFICATION C5-79

| | Calcium Lime | Magnesium Lime |
|---|---|---|
| Calcium oxide, min, % | 75 | - |
| Mgnesium oxide, min, % | - | 20 |
| Calcium and magnesium oxide, min, % | 95 | 95 |
| Silica, alumina, and oxide of iron, max, % | 5 | 5 |
| Carbon dioxide, max, % | | |
| If sample is taken at place of manufacture | 3 | 3 |
| If sample is taken at any other place | 10 | 10 |

FINISHING HYDRATED LIME
SPECIFICATION C206-84

| | Type N | Type S |
|---|---|---|
| Calcium and magnesium oxides (nonvolatile basis), min, % | 95 | 95 |
| Carbon dioxide (as-received basis), max, % | | |
| If sample is taken at the place of manufacture | 5 | 5 |
| If sample is taken at any other place | 7 | 7 |
| Unhydrated oxides (as-received basis), max, % | - | 8 |

*Type* *N - Normal*
*S - Special*

HYDRAULIC HYDRATED LIME FOR STRUCTURAL PURPOSES
SPECIFICATION C141-85

| | Min | Max |
|---|---|---|
| Calcium and magnesium oxides (CaO and MgO calculated to the nonvolatile basis), % | 65 | 75 |
| Silica ($SiO_2$ calculated to the nonvolatile basis), % | 16 | 26 |
| Iron and aluminum oxides ($Fe_2O_3$ and $Al_2O_3$ calculated to the nonvolatile basis), % | - | 12 |
| Carbon dioxide ($CO_2$ on an as-received basis), % | - | 8 |

HYDRATED LIME FOR MASONRY PURPOSES
SPECIFICATION C207-79

| | Hydrate Types | | | |
|---|---|---|---|---|
| | N | NA | S | SA |
| Calcium and magnesium oxides (nonvolatile basis), min, % | 95 | 95 | 95 | 95 |
| Carbon dioxide (as-received basis), max, % | | | | |
| If sample is taken at place of manufacture | 5 | 5 | 5 | 5 |
| If sample is taken at any other place | 7 | 7 | 7 | 7 |
| Unhydrated oxides (as-received basis), max, % | - | - | 8 | 8 |

*Type* *N - Normal*
*NA - Normal air-entraining*
*S - Special*
*SA - Special air-entraining*

Another technical development affecting the use of lime in the steel industry is increased use of hot iron desulphurization and the use of magnesium as the desulphurization agent. In hot metal desulphurization molten iron from the blast furnace is treated prior to entering the BOF. The fluxing agent may be lime, calcium carbide, or magnesium powder. Calcium carbide is typically employed in Japan and Europe, although there is a trend to the use of magnesium powder. In Canada and the United States the magnesium powder is often treated with a lime coating to yield a lower cost fluxing agent.

## OTHER METAL SMELTING

Lime is used as a fluxing agent to promote slag formation in the smelting of copper, lead, zinc, and antimony. It is used in the flotation process for copper production for pH adjustment and as a settling agent, in the recovery of gold and silver in the cyanide flotation process, used in the recovery of nickel by precipitation after it is smelted. Lime is used in the Bayer process for the manufacture of alumina, where the lime causticizes sodium carbonate solutions to generate sodium hydroxide, and in the secondary desilification process. In acid–type uranium extraction, lime is used to neutralize waste acid liquors. Other uses of lime include the recovery of tungsten from scheelite and the recovery of high cost flotation agents such as xanthates in zinc, nickel, and lead flotation mills.

## PULP AND PAPER

High calcium lime is used to causticize the "black liquor" (sodium carbonate solution) to sodium hydroxide in the sulphate pulping (kraft) process. Most kraft pulp mills recover the calcium carbonate sludge after the causticizing process by dewatering and calcining. Approximately 92% to 98% of the lime is recovered, the balance being made up by purchases of quicklime or high calcium stone.

Some lime is still used in the sulphite pulping process, although most bisulphite pulping liquors are now derived by reacting $SO_2$ with limestone or other alkaline bases such as ammonia, magnesia, and soda ash. Lime is also used for the production of calcium hypochlorite for pulp bleaching.

## CHEMICAL MANUFACTURE

A diverse range of chemicals may be prepared from lime. The principal chemicals produced are the sodium alkalis (sodium carbonate, sodium bicarbonate, sodium hydroxide) by the Solvay process, which requires large quantities of salt brines and $CO_2$ as well as ammonia. The purpose of the lime is to causticize sodium carbonate to sodium hydroxide and to regenerate the ammonia catalyst in the manufacture of soda ash. The process used by General Chemical Canada Ltd., the only Solvay soda ash producer in Canada, is illustrated in Figure 3.10.

Lime is also used in the production of the following chemicals:

- calcium carbide for acetylene production
- calcium cyanimide, a nitrogen fertilizer
- inorganic insecticides and pesticides such as arsenates, Bordeaux mixtures, and lime–sulphur sprays and powders
- magnesium and calcium oxides and hydroxides, calcium chloride, inorganic salts, chrome chemicals, hydroxides of lithium, barium, etc., and the purification of brines for food grade sodium chloride
- ethylene glycol via the chlorohydrin process and the production of propylene oxide and glycol
- azo dyes
- napthol via the sulphuric acid process
- benzaldehyde and benzoic acid from dichlorotoluene and trichlorotoluene
- precipitated calcium carbonate from soda ash manufacture or carbonation of milk–of–lime.

## ENVIRONMENTAL USES

Lime is extensively used for environmental purposes. These uses include the following:

- Neutralization of waste acid liquors and gases from ferrous and non–ferrous metals smelters and refineries;
- Neutralization of organic and inorganic acid wastes from chemical plants, pulp and paper mills, textiles plants, and food processing plants;
- Water softening, purification, and coagulation (turbidity removal) for potable and process water and boiler feed water;
- Sewage treatment and phosphate removal and sewage sludge neutralization and precipitation;
- Scrubbing of acid gas emissions from thermal power plants and boilers.

These uses are more advanced in the United States than in Canada. Water, gaseous, and sewage treatment accounted for approximately 29% of U.S. demand for lime in 1985 versus approximately 5% in Canada in 1983. The main differences are accounted for in scrubbing of acid gases and in sewage treatment.

## GLASS AND CERAMICS

Dolomitic lime is used as the source of magnesium oxide in glass–making. Both high calcium and dolomitic limes are used to manufacture special refractories and silica brick for use in cement kilns, steel furnaces, and other high temperature industrial furnaces.

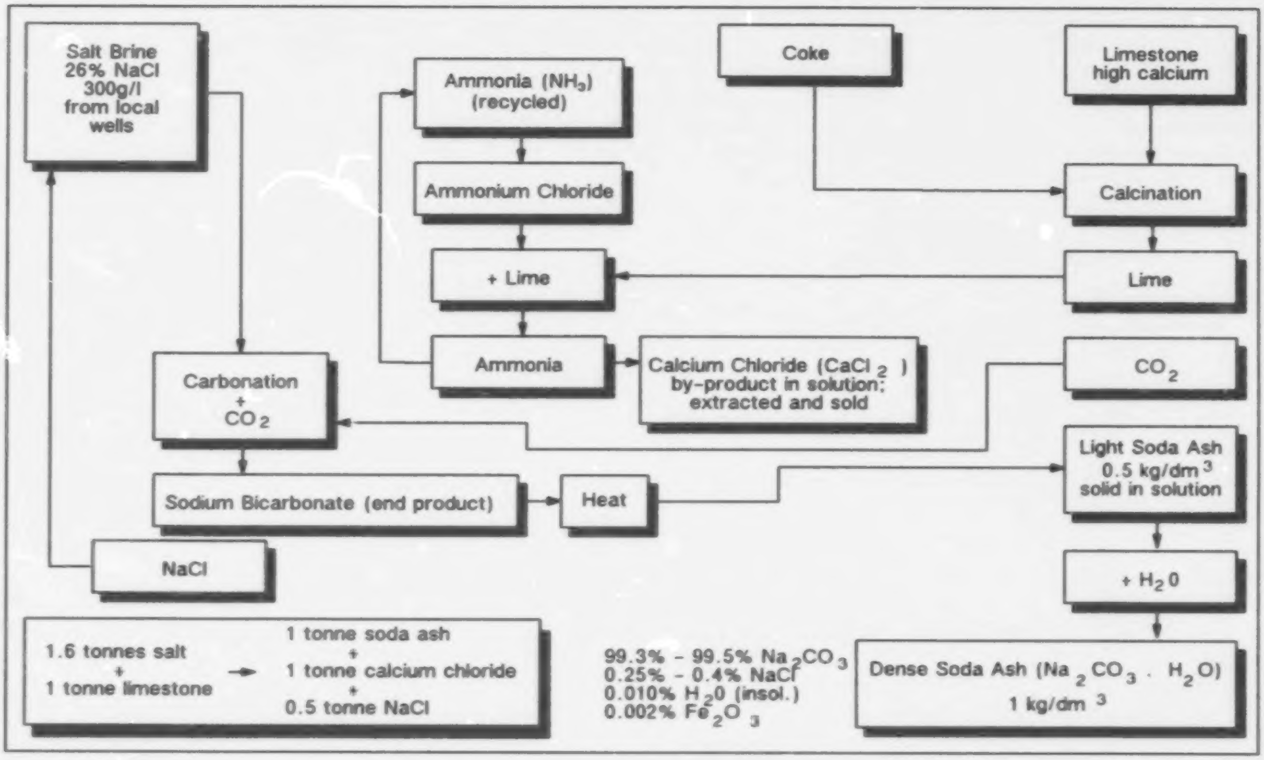

Salt Brine 26% NaCl 300g/l from local wells
Ammonia (NH₃) (recycled)
Coke
Limestone high calcium
Ammonium Chloride
Calcination
+ Lime
Lime
Ammonia
Calcium Chloride (CaCl₂) by-product in solution; extracted and sold
CO₂
Carbonation + CO₂
Light Soda Ash 0.5 kg/dm³ solid in solution
Sodium Bicarbonate (end product)
Heat
NaCl
+ H₂O
1.6 tonnes salt + 1 tonne limestone → 1 tonne soda ash + 1 tonne calcium chloride + 0.5 tonne NaCl
99.3% - 99.5% Na₂CO₃
0.25% - 0.4% NaCl
0.010% H₂O (insol.)
0.002% Fe₂O₃
Dense Soda Ash (Na₂CO₃ · H₂O) 1 kg/dm³

**Figure 3.10. SOLVAY PROCESS FOR THE MANUFACTURE OF SODA ASH.**

## BUILDING PRODUCTS

Lime is used as the raw material for the manufacture of calcium silicate building products such as sand–lime brick, cellular concrete blocks, and silicate concrete. These products have achieved much greater market acceptance in Europe and Japan than in North America, where concrete is the primary building material.

## FOOD PROCESSING

Lime is extensively used in the food processing industry as a precipitating agent and for waste disposal. The sugar refining industry is the major user, and many sugar mills have captive lime plants associated with them. This is especially true of sugar beet processing plants which produce large volumes of acid waste and require large amounts of lime for the clarification process.

Lime is used in the production of gelatin, in dairy processing, the baking industry, fruit processing, and controlled atmosphere apple storage.

## OTHER INDUSTRIAL USES

Other uses of lime include the following:

- Petroleum refining; for mercaptan removal, $SO_2$ gas removal, lubricating grease production, "red lime mud", drilling mud conditioning, etc.;
- dehairing and plumping of hides in tanneries;
- paint, pigment, and varnish manufacture;
- rubber manufacture;
- chemical dehydration of organic chemical compounds.

## AGRICULTURAL USES

Lime is used in agriculture for soil neutralization, composting, fertilizer manufacture, chicken litter disinfection, etc. These uses represent only a small portion of total demand.

## CONSTRUCTION

Construction uses for lime include the following:

- masonry mortar, stucco, and base coat plaster;
- hydraulic lime;
- lime–cement mortar.

These uses are more common in Europe than in North America. Dolomitic rather than high calcium lime is generally preferred.

## SOIL STABILIZATION

Soil stabilization is a significant use of lime in the United States, but is a limited end–use in Canada. The lime reacts with most types of clay soils by agglomerating the clay particles through base exchange and chemically reacting with the silica and alumina in the soil, forming complex calcium and aluminum silicates. Lime can also be used in deep soil stabilization projects such as underwater construction of bridge piers. In this case special injection equipment is required to inject the lime solution under high pressure. Finally, hydrated lime is used as an anti–stripping agent for asphalt mixes, especially siliceous aggregates.

## CHEMICAL PROCESS STONE

Crushed limestone and dolostone are used to make glass more insoluble. During the glass–making process the limestone and/or dolostone acts as a flux for the melting sililca sand, forming chemically fused calcium and/or magnesium silicates. High calcium limestone is used in the manufacture of flat or window glass, while dolostone is used in the manufacture of glass containers and tumblers, and in the manufacture of glass fibre. The higher MgO content in glasses made from dolostone confers greater acid etching resistance and increases the thermal shock resistance of the glass.

Limestone and dolostone used in glass manufacture must be low in iron, at least below 0.06% FeO. Iron limits could be as low as 0.014% (or lower) for some glasses. Stone is crushed to sizes of 0.74 mm to 2.4 mm. Typical chemical specifications are given in Table 3.11.

**Table 3.11. CHEMICAL SPECIFICATIONS FOR LIMESTONE AND DOLOSTONE IN GLASS MAKING.**

| | Limestone | Dolostone | Dolomitic Lime |
|---|---|---|---|
| $SiO_2$ | 0.5%–2.0% | 1.0% | 0.6% |
| $Al_2O_3$ | 0.2%–0.4% | 0.1%–0.3% | |
| $Fe_2O_3$ | 0.05%–0.15% | 0.15%–0.30% | 0.2% |
| $TiO_2$ | 0.01% | | |
| CaO | 53.55%–56.0% | 29%–31% | 55% |
| MgO | 0.4%–1.2% | 19%–22.5% | 38% |
| $Na_2O + K_2O$ | 0.03%–0.15% | | |
| $As_2O_3$ | | | 0.01% |
| $P_2O_5$ | 0.01%–0.1% | 0.10% | 0.01% |
| L.O.I. | 42.0%–44.0% | | 2.0% |
| Moisture | 0.1% | 0.1%–0.5% | |

Source: Boyton, 1980.

## PULP AND PAPER

Pulp and paper mills use limestone as supplementary material to make up their lime requirements for the recausticization of the spent sulphite pulping liquor. The stone is added to the lime kiln during the calcining of the sulphite sludge. Requirements are modest and vary from year to year depending on the performance of the kiln and the relative costs of lime and limestone. Very limited amounts of magnesia or dolostone are used in sulphite pulp mills to prepare magnesium sulphite.

## SODA ASH (SODIUM CARBONATE) MANUFACTURE

High calcium limestone is used in the production of soda ash by the Solvay process. The process has largely been supplanted by the use of natural soda ash, trona, from Wyoming. There is only one Canadian producer of soda ash, General Chemical Canada Ltd. in Amherstburg (site CH–1 in the Chatham District chapter, Volume III), and only one remaining U.S. producer. General Chemical produces calcium chloride, sodium bicarbonate, and a range of other calcium and sodium compounds or by–products and co–products of the Solvay process. Approximately 1.6 tonnes of salt and 1 tonne of limestone are required to produce 1 tonne of soda ash, 1 tonne of calcium chloride and 0.5 tonne of sodium chloride. The salt is recycled in the production process.

## METALLURGICAL STONE

Crushed limestone and dolostone are used as a flux in ferrous and non– ferrous smelting and refining as a cheap substitute for the more expensive lime. The crude crushed material is also preferred for technical reasons in some applications. The major use of crushed limestone and dolostone in the metallurgical industries is in the steel industry. High calcium stone or lime are used as a flux in open hearth steelmaking, though this use is rapidly declining as the last two open hearth furnaces in Canada will be closed by the end of 1989 with the conversion of Stelco's Hilton Works in Hamilton, Ontario, and Sysco Steel in Sydney, Nova Scotia, to full Basic Oxygen Furnace production. Limestone and dolostone are also used directly in the manufacture of self–fluxing sinter and pellets. The Iron Ore Company of Canada started production of self–fluxing pellets at Wabush and Labrador City in 1985, using calcium limestone and dolomitic stone shipped from Ontario. Algoma Steel Corp. Ltd. produces self–fluxing sinter at its Wawa sinter plant using high calcium stone and dolostone from U.S. and Canadian sources. Dofasco Inc. produces self–fluxing pellets at the Adams Mine in Kirkland Lake and the Sherman Mine in Temagami, Ontario, for its steel production facilities in Hamilton.

Magnesium and calcium metal production is the other major metallurgical market for dolostone and high calcium limestone. Timminco Ltd. produces both metals using a variant of the alumino–silicothermic Pidgeon process at its plant at Haley, Ontario (site PE–6 in the Pembroke District chapter, Volume II).

# Fillers and Extenders

Fillers and extenders are finely ground mineral materials used in a wide range of industrial applications. They may be used as low cost additives to increase the bulk of many commercial products, to improve the physical properties of the product, or for both purposes, adding important properties of their own without seriously decreasing the important characteristics of the product. The materials are also known as mineral extenders because they extend (and usually enhance) the properties of the products in which they are used.

There are a wide variety of extenders and fillers. The principal materials used are:

- carbonate materials such as calcium carbonate and magnesium carbonate
- kaolin
- barytes
- mica
- silica
- talc
- aluminum trihydrate (ATH)
- glass, ceramic, and plastic beads

Other mineral and organic based materials may also be used in limited quantities.

Carbonate–based mineral fillers and extenders are by far the most widely distributed and used materials, and their market has expanded rapidly in recent years. The development of processing technologies for the production of ultrafine grind carbonate materials, combined with changes in the manufacturing processes for many end–use applications, has greatly extended the application scope for carbonate fillers and extenders. The development of new markets and new products has also resulted in a considerable increase in the value–added of many carbonate derived fillers and extenders.

Carbonate fillers and extenders may be derived from limestone, dolostone, marble, calcite and marl, or synthetically produced as precipitated calcium carbonate or hydrated magnesium carbonate. White, high purity marble is the most common source of carbonate mineral fillers. Calcitic carbonates are extensively used as a paper filler and in paint, plastics, linoleum, and rubber. Important properties of filler grade carbonates include whiteness, fineness, freedom from grit, low oil absorption, and particle shape. Transportation charges play a major role in determining the market opportunities available to a producer, as well as competition from substitute materials.

## ONTARIO OCCURRENCES AND PRODUCERS

Ontario carbonate sources include limestone, dolostone, marble, carbonatite, marl, and vein deposits. Limestone dust, produced during the quarrying and processing of limestone and dolostone for cement, lime, or construction aggregate, can be used as a filler in asphalt and other applications where colour is not important. Marl and vein calcite have been used in limited amounts in the past, but are not being used today.

Marble is the principal source of filler grade carbonate in Ontario, and has the greatest potential for market expansion and new product development. Marble in Ontario is generally restricted to the southern portion of the Grenville area of the Precambrian Shield.

Steep Rock Calcite, a division of Steep Rock Resources Inc., is the principal producer of carbonate fillers in Ontario*. The company operates a large, high–purity calcite marble quarry at Tatlock in southeastern Ontario. Primary crushed material is transported to a modern crushing and grinding plant at Perth, where material suitable for a variety of end–uses is produced using both dry and wet grinding circuits. A description of the quarry and plant is given in site CP–25 of the Carleton Place District chapter, Volume II. Previous attempts to produce filler grade calcium carbonate from other Grenville deposits, as well as calcite veins and marl beds, have generally been unsuccessful. These earlier investigations and workings of deposits are described in Guillet and Kriens (1984), Guillet (1969), and Hewitt (1964).

There are several producers of low grade off–white calcitic fillers in southern Ontario. BeachviLime Limited (site A–3 in the Aylmer District chapter, Volume III) between Beachville and Ingersoll produces industrial fillers as a by–product of limestone aggregate and glass grade production. The material is a coarse (200 to 325 mesh) product used in carpet backing, caulking compounds, asphaltic roofing products, and automotive undercoatings. Steetley Lime and Aggregates, a division of Steetley Industries Ltd. (site CB–11 in the Cambridge District chapter, Volume III), produces dolostone fillers at its aggregate and pulverized stone plant near Dundas. The filler products are produced from fines resulting from the production of glass grade dolostone, fertilizer diluents, and agricultural dolostone. The fillers are sold primarily for use in asphaltic roofing. Owen Sound Dolomite, a division of E.C. King Contracting of Owen Sound (site O–10 in the Owen Sound District chapter, Volume

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** At the time of printing, the operations and shares of Steep Rock Calcite were being purchased by MAS Minerals Corp., a wholly–owned subsidiary of Pluess–Stauffer AG of Switzerland.*

III) produces dolostone fillers in conjunction with glass grade dolostone. The fillers are used in asphaltic roofing and sealer applications.

## EXTRACTION AND PROCESSING

Carbonate materials for filler and extender uses are normally mined by quarrying. In the United States, however, there are a large number of underground operations. These underground operations generally employ the room and pillar method and are usually higher cost operations than open pit producers. Open pit mining methods for fillers and extender grade materials are similar to conventional quarrying for limestone and dolostone aggregate. Selective quarrying may be required on occasion to avoid areas of waste rock and meet the stringent quality requirements. It is generally desirable to have a number of working faces in the quarry to provide flexibility to the operation and allow for blending where quality variations occur.

Development of a suitable deposit should include removal of overburden, including final clean–up by pick and shovel or hydraulic washing. Extensive diamond core drilling is usually necessary to adequately define the limits and quality variations of the deposit. Large uniform deposits may lend themselves to contract mining. For example, the deposit of Steep Rock Calcite at Tatlock is worked only a few weeks each summer, when sufficient crushed material is stockpiled at the Perth processing plant for the year's needs.

Processing methods for carbonate fillers are dependent upon the mineralogical and chemical purity of the raw material and the product quality requirements of the consuming industries. Processing choices are generally directed to producing materials suitable for the broadest possible range of applications within the market area of the producer. Because of this there are a variety of processing plants, which can generally be classified into six categories:

1. Plants producing by–product fillers from fines generated during the production of aggregate and other non–filler products.
2. Plants producing aggregate and other non–filler products, but with dedicated filler production facilities using dry grinding and air classification.

These first two types of plants produce fillers of low quality from off– white limestone and dolostone for local markets.

3. Plants producing high quality fillers using dry grinding and air classification.
4. Plants producing high quality fillers using wet grinding, flotation, wet grinding classification using centrifuges or cyclones, and filtration and drying.

These plants are conventional filler producers which meet the requirements of most consumers except those requiring ultrafine particle sizes.

5. Plants producing fillers using a combination of wet and dry processing techniques.
6. Plants producing ultrafine grind fillers using special wet grinding techniques, classifying centrifuges, and spray dryers.

These plants produce ultrafine grind products of less than 5 microns particle size.

Recent technological developments have concentrated on improvements to both wet and dry grinding systems for the production of very fine grind materials. The processes employed are often proprietary and very little information is available on their exact nature. Another development of major interest is the increasing interest in coated calcium carbonate using stearates or coupling agents. Surface coating technology is developing rapidly and is enabling filler producers to enter new markets and/or significantly increase the value–added of their products in existing markets. Many carbonate filler producers now make customized products for dedicated customers.

Figure 3.11 illustrates the typical flow of carbonate materials in either a dry or wet process plant. Primary and secondary crushing generally employ the same type of equipment as is used in aggregate production. Primary crushing is usually accomplished using jaw or gyratory crushers. Impact crushers may be used if the material is soft and free from silica. Secondary crushing is generally conducted using cone or impact crushers, usually in closed circuit with vibratory screens. Autogenous or semi–autogenous mills may also be used if the material is suitable.

Tertiary crushing and primary grinding is accomplished using a variety of equipment. The choice depends upon the later processing requirements. Roll crushers, roller mills, cage mills, rod mills, and ball mills may be used to provide feed for a fine grinding circuit or for a froth flotation circuit.

Further processing of the material may include fine grinding and classification. Roller mills are typically used to produce medium to fine filler products (up to 99% passing 325 mesh, 44 microns). Ball mills, pebble mills, and vibratory mills are used for fine grinding. The equipment is usually operated in closed circuit with air classifiers. Conventional ball or pebble mills are used to grind products ranging from 100 to 325 mesh. Vibratory mills and the new agitator mills using air classifiers and cyclones or classifying centrifuges can grind to even finer sizes of less than 5 microns with very tight particle size distributions. Grinding aids based on organic liquids may be employed to assist in the ultrafine grinding process and prevent the formation of agglomerates. Surface coat-

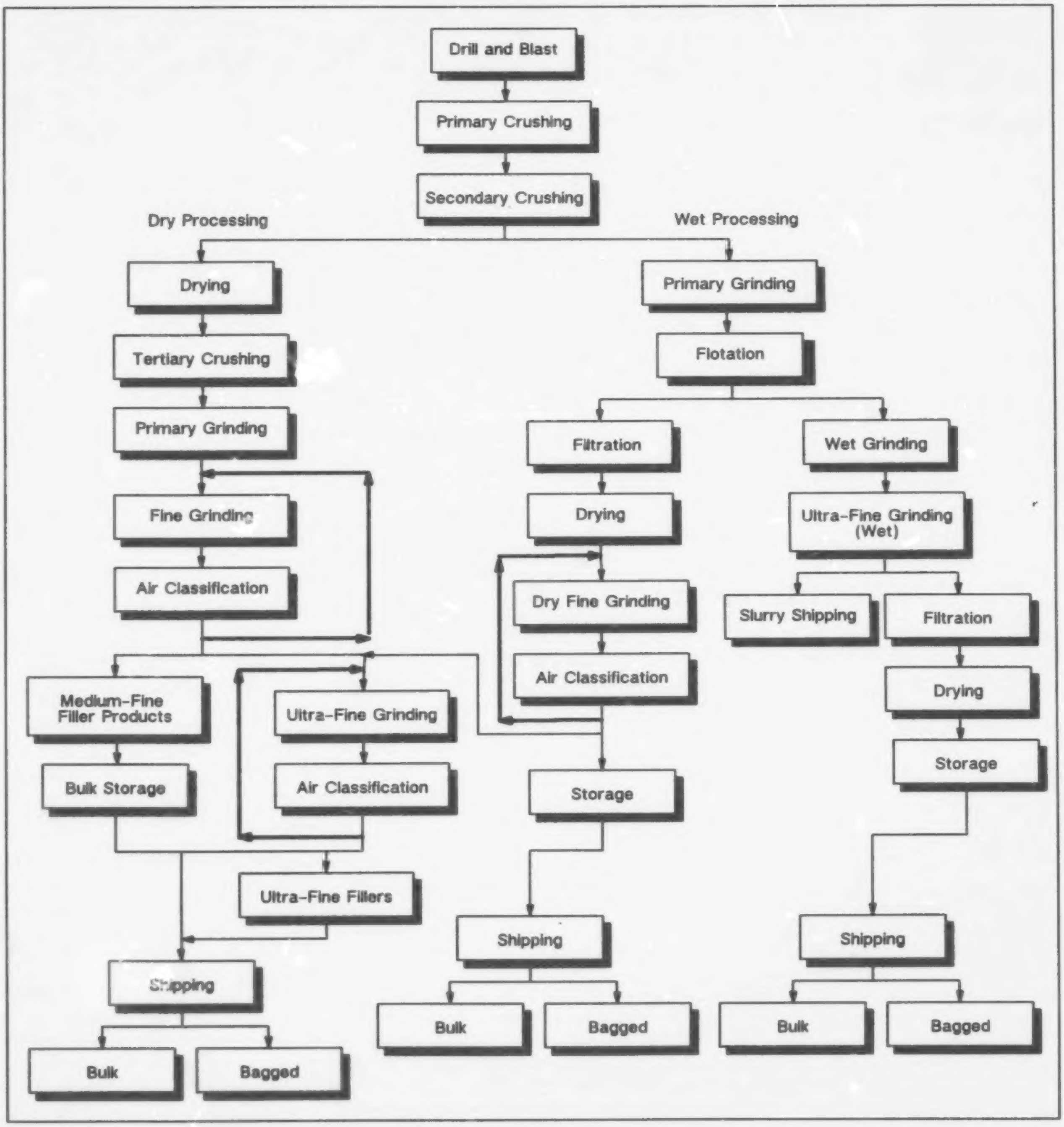
Drill and Blast
Primary Crushing
Secondary Crushing
Dry Processing
Wet Processing
Drying
Tertiary Crushing
Primary Grinding
Fine Grinding
Air Classification
Medium-Fine Filler Products
Bulk Storage
Ultra-Fine Grinding
Air Classification
Ultra-Fine Fillers
Shipping
Bulk
Bagged
Primary Grinding
Flotation
Filtration
Drying
Dry Fine Grinding
Air Classification
Storage
Shipping
Bulk
Bagged
Wet Grinding
Ultra-Fine Grinding (Wet)
Slurry Shipping
Filtration
Drying
Storage
Shipping
Bulk
Bagged

**Figure 3.11.** CONCEPTUAL FLOWSHEET - CALCIUM CARBONATE PRODUCTION, DRY OR WET PROCESSING ALTERNATIVES. *Source: Guillet and Kriens, 1984.*

**Table 3.12. GRADE DESIGNATIONS AND TYPICAL PROPERTIES OF CALCIUM CARBONATE.**

| Grade (ASTM-D-1199) | Fine paint Grade I | Coarse paint Grade II | Grade II | Filler Grade III | Putty powder Grade IV | Superfine Grade V |
|---|---|---|---|---|---|---|
| **Particle size analysis** | | | | | | |
| % Retained on 325 mesh | 0.05 | 0.5 | 0.0 | <25 | <30* | 0.0 |
| Particle size range (microns) | 0.5-20.0 | 0.5-45.0 | 0.5 | 10-45.0 | 40.0 | 0.05-5.0 |
| Specific surface diameter (maximum, microns) | 2.5 | 6.0 | | 9.0 | 12.0 | 1.0 |
| Mean particle size (microns) | 3.0 | 7.0 | 13.0 | 17.5 | 36.0 | |
| Hegman grind | 6-6.25 | 4-4.25 | | | | |
| **Physical properties** | | | | | | |
| Oil absorption | 14.0-16.0 | 12.0-14.0 | | | | |
| Bulk density (lb/ft$^3$) | 49.0 | 62.0 | 64.0 | 69.5 | 74.0 | |
| Bulking value (gal/lb) | 0.0443 | 0.0443 | 0.0443 | 0.0443 | 0.0443 | 0.0443 |
| Specific gravity | 2.71 | 2.71 | 2.71 | 2.71 | 2.71 | 2.71 |
| Specific resistance (ohms) | 20,000 | 20,000 | 20,000 | 20,000 | 20,000 | 20,000 |
| pH | 9.4 | 9.4 | 9.4 | 9.4 | 9.4 | 9.4 |
| Hardness (Mohs) | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Refractive index (mean) | 1.59 | 1.59 | 1.59 | 1.59 | 1.59 | 1.59 |
| Dry brightness (minimum) | 96.0 | 94.0 | 93.0 | 85.0 | 90.0 | 96.0 |
| **Chemical composition** | | | | | | |
| % Calcium carbonate | 98.00 | 98.00 | 98.00 | 95.00(min) | 95.00(min) | 98.50 |
| % Magnesium carbonate | 0.60 | 0.60 | 0.60 | 3.00(max) | 3.00(max) | 0.60 |
| % Silica | 0.50 | 0.50 | 0.50 | 1.00 | 1.00 | 0.40 |
| % Iron oxide | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.02 |
| % Alumina | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 | 0.20 |
| % Moisture | 0.02 | 0.02 | 0.02 | 0.15 | 0.15 | 0.02 |

**% retained on 200 mesh screen*

*Applicable tests:*

*Moisture: Method A of method D-281.*

*Specific surface diameter: Practice D-1366.*

*Dispersed colour: Method D-718.*

*Oil absorption: Method D-281.*

*Particle size: Method D-3360.*

*Coarse particles: Method D-718.*

*Dry brightness: Method E-97.*

*Source: after Guillet and Kriens, 1984.*

ings may also be employed to improve the properties of ultrafine grind fillers.

## SPECIFICATIONS

The most significant considerations in selecting calcium carbonate as a filler are:

- particle size
- whiteness (brightness)
- mineralogical and chemical purity.

### PARTICLE SIZE

Commercial grades of carbonate fillers cover the size range from 100 mesh (144 microns) to the sub-micron level. Five standard grades are recognized by the ASTM under standard D-1199. Within each grade are a number of filler products that fall within the specifications published for these grades. The ASTM specifications and some examples of grades falling within each grade division are provided in Table 3.12.

Many producers and consumers have developed their own specifications for carbonate fillers based upon the results of development work which identifies superior performance characteristics for such "non-standard" products. It is not unusual for a filler producer to provide exclusive grades to particular customers.

Particle size distribution is a critical parameter in most end-use applications. Changes in particle size distribution can cause a considerable change in product performance. For example, oil absorption of a filler is a function of its surface area. The packing density of the particles affects oil absorption as well as the viscosity of aqueous and organic systems. Particle size control is therefore one of the most important factors in the success of a filler manufacturer. Other significant physical and chemical parameters are bulk density, pH, bulking value, specific gravity, specific resistance, hardness, and refractive index.

### WHITENESS

Whiteness and brightness are closely related factors and are important in carbonate fillers in applications such as paint, plastics, and paper. Other, less demanding, appli-

**Table 3.13. PRIMARY USES FOR CARBONATE FILLERS.**

| Application | Function | General Specifications |
|---|---|---|
| Paint | Extender of prime pigments in interior and exterior paint formulations. | High whiteness; controlled particle size, 44 microns to 8 microns top size. |
| Plastics | As a resin extender in a wide range of polymer systems. | High whiteness; controlled particle size, 30 to 5 microns top size; fillers treated with coatings and coupling agents are used. |
| Paper | As a filler or for paper coating. Partial displacement of kaolin. | High whiteness; controlled particle size, low abrasion, very fine products with top sizes ranging from 10 to 4 microns. |
| Putty, caulking, sealing | | White, medium to fine, 90-99% passing 325 mesh (44 microns). |
| Vinyl floor covering | As a filler in vinyl tile. | Coarse granular (-40 mesh) to fine (-325 mesh); good white colour; controlled particle size and bulk density. |
| Carpet backing | | White to gray colour; 90%-99% passing 325 mesh. |
| Asphaltic products | Filler in roofing materials and asphalt sealers. | Off-colour buff to gray; coarse ranging from 80% passing 325 to 80% passing 200 mesh. |
| Rubber | Filler pigment in footwear, automotive goods, non-reinforced rubber, wire and cable coatings. | White to off-colour; fine to medium fine products. |
| Construction | Filler in jointing compounds for gypsum board. | Lower grade white products; 90-95% passing 325 mesh. |
| Other | Synthetic marble. | White, coarse products; 80-85% finer than 200 mesh, and granular grades. |
| | Coal dusting. | White to buff, coarse filler used in coal mining. |

*Source: Guillet and Kriens, 1984.*

cations such as asphaltic roofing and sealers, carpet backing, jointing and caulking compounds, etc. can utilize off-white carbonate fillers, provided the material meets other specifications such as particle size, freedom from grit, oil absorption, etc.

There are a variety of methods to determine brightness and whiteness and producers usually state the method used to avoid confusion. Some industry groups such as the paper industry have developed their own standard test procedures, and filler producers generally employ these methods if selling to that market.

### MINERALOGICAL AND CHEMICAL PURITY

Carbonate fillers should be as free as possible from deleterious materials such as quartz or other abrasive particles, arsenic, lead, water soluble salts, and dark minerals. If these materials are present additional and costly processing may have to be conducted to produce acceptable material.

## USES

Calcium carbonate is used as an extender and filler in a broad range of applications. The principal end-use markets are plastics, paint, paper, adhesives and sealants, rubber, drywall compounds, and carpet backing. These applications are summarized in Table 3.13 and discussed in detail in the following sections.

### PLASTICS

Mineral fillers are used in plastics as a resin extender and to improve some of the physical properties of the resin. Surface coatings and/or coupling agents have been employed in the development of new grades of fillers which considerably enhance the properties of the filler. Fillers are now used not only as low cost bulking agents, but also to impart beneficial properties to the resin. In most cases they are now regarded as functional fillers.

Calcium carbonate, however, is used to supply bulk at low cost and is mostly a non-functional filler. Typical size ranges used are in the 1 micron to 20 micron range. The more expensive ultrafine sizes may be used to provide functional properties such as improved mar and impact resistance, improved gloss, and improved cold flow properties in the compounding process. Precipitated calcium carbonate is included in the ultrafine sizes, but the volumes used are small.

The main uses in plastics for calcium carbonate are in PolyVinyl Chloride (PVC) and thermosetting polyesters. Calcium carbonate in PVC is found in both flexible and rigid materials. Calendered or flexible vinyl for applications such as furniture uses a 3.0 micron material at loadings of 15% to 20% or 20 to 60 phr (parts per hundred of resin). Thinner vinyls use finer grades of filler.

Table 3.14. SUMMARY OF APPLICATIONS FOR CALCIUM CARBONATE FILLER IN PLASTICS.

| Polymer | Filler Level phr* | Particle Size Microns | Remarks |
|---|---|---|---|
| Flexible PVC | 20–60 | 3 | Compared with coarser grades, fine fillers cause less of a decrease in physical properties and provide better performance in thinner calendered films and coatings. |
| PVC plastisols and organisols | 20–100 | wide range | Coarse grades for carpet backings to ultra fine precipitated grades and coated chalk whiting for thixotropic viscosity control. Coarse particles lead to lower viscosity in plastisols. |
| Rigid PVC | 1–5<br>40 | 2–3<br>1–3 | Application in plastic for potable water pipe. Other pipe and conduit applications. Stearate-coated grades improve melt rheology and smoothness of extrusion; uncoated grades serve as antiplate-out agents. |
| PVC floor tile | 80–400 | small | Finest grind is about 12 microns; size distribution is wide; colour varies with feedstock. |
| Sheet moulding compound | 250 | 3–6 | Loadings are usually 250 phr for BMC, 100–150 phr for premix preform, and mat-over 400 phr is possible. Size distribution, and purity are selected to provide low-uniform-viscosity polyester. |
| Marine polyester | 175–200 | 3–5 | Meets standard requirements for this application of 0.15% maximum water absorption during a 24 hour immersion. |
| Polypropylene | 43–67 | 1–3 | For both polypropylene homopolymer and copolymers. |

**parts per hundred of resin*
*Source: Guillet and Kriens, 1984.*

Rigid PVC applications for calcium carbonate include pipe and mouldings, windows and doors, floor tile, etc. Pipe producers currently use 2–3 micron material at loadings of 1–5 phr for potable water pipe and up to 40 phr for other pipe and conduit. There is a push by some manufacturers to increase calcium carbonate loadings in pipe by up to 50%, but this will require changes in government specifications for pipe. PVC floor tile calcium carbonate loading levels are in the range of 80 to 400 phr of small granular sizes (–40 to –325 mesh). In PVC plastisols and organosols such as carpet backing loading levels of 20 to 100 phr of (generally) 325 mesh material are common.

Polyesters have been the largest growth area for calcium carbonate in plastics. Typical mineral reinforced polyester formulations contain 20% chopped glass fibres, 35% to 40% resin, and 40% to 45% calcium carbonate by weight. Calcium carbonate is used in both sheet moulding compound (SMC) and bulk moulding compound (BMC), with higher loadings being found in BMC. The automobile industry is the principal end-user of these products, accounting for approximately 75% of the market, mainly for the front-end panels of cars (SMC) and truck hoods, fenders and front end panels (BMC). Calcium carbonate in these applications acts both as a filler and to control the viscosity, shrinkage, part weight, surface appearance, and maturation rate of the mix.

Calcium carbonate may also be used as a filler in other plastics, e.g. polypropylene. Typically, polypropylene for automotive applications is loaded with about 40% talc to increase the flexural modulus of the material to approximately 600,000 psi from the unfilled level of approximately 200,000 psi. A 40% loading of calcium carbonate gives a flexural modulus of about 400,000 psi. This provides a material competitive with Acrylonitrile Butadzene Styrene (ABS), but at reduced cost. The use of fine grade material in polypropylene will also increase its impact resistance. Table 3.14 summarizes the applications for calcium carbonate fillers in plastics.

## PAINTS

Calcium carbonate is used as an extender in oil, alkyd, acrylic, and latex- based paint systems. The key parameters used by paint manufacturers to evaluate fillers are:

- oil absorption
- fineness
- particle size distribution
- whiteness (brightness)
- freedom from abrasive components such as silica

- pH
- water solubility
- chemical composition
- bulk density

Low oil absorption is of particular interest as this will allow for higher loadings while providing otherwise equivalent properties.

Coarse sized fillers of approximately 7.0 micron (44 micron top) are used in flat (low sheen) paints. Even coarser grades, 10 mesh and down, are used in textural paints and concrete block sealers. Semi–gloss and high gloss paints use finer grades of fillers. For example, a typical high gloss alkyd paint will use a 3.0 micron or less grade. Some high gloss paints use ultrafine fillers of 0.7 micron average particle size (90% below 2 microns). These ultrafine fillers are extremely efficient extender pigments and have substantial dry hide characteristics on their own. They have a lower oil absorption than calcined kaolin and can substitute to approximately 20% for the prime pigment, generally titanium dioxide ($TiO_2$). Loadings for paints are typically up to 300 mg per litre for flat and semi–gloss paints and 100 mg per litre for glossy paints.

## PAPER

The use of calcium carbonate as a filler and coating material in paper manufacture is relatively new. Three developments opened up the market to natural ground calcium carbonate: first, a decline in the availability of precipitated calcium carbonate as the Solvay process for production of soda ash was displaced by high quality natural soda ash and trona. More recently, though, Pfizer, the largest precipitated calcium carbonate producer, has entered into arrangements to design, build and operate PCC plants at several paper companies. These plants utilize waste $CO_2$ from the lime reburn kiln and other raw materials. They thus provide a ready and relatively inexpensive source of high quality filler material. Second, the development of ultrafine wet grind technology to produce high solids carbonate slurry materials in the 0.6 micron to 0.8 micron size range; and third, the switch from acid sizing using alum to neutral and alkaline sizing materials, thus permitting the use of calcium carbonate as the filler material.

Alkaline sizing offers a number of advantages over acid sizing. Among these are:

1. It permits the use of less expensive hardwood pulps, which are more affected by acid media than are softwood pulps.
2. It permits higher filler loadings than does acid sizing using kaolin as the filler. Loadings up to 20% higher are possible, thus reducing fibre cost.
3. It allows for reduced maintenance costs by the elimination of corrosion causing acid constituents.
4. It allows for a reduction in effluent treatment as neutralization of effluent water is no longer required. White water from neutral and alkaline sizing operations can be recycled in the mill.
5. Energy costs are reduced due to lower water, steam, and heat consumption.
6. It provides for higher brightness and/or a reduction in the use of $TiO_2$ and optical brighteners.
7. It provides for higher strength paper by eliminating acid deterioration of the paper and by promotion of fibre hydration, resulting in easier processing and increased yield.
8. It provides for a more permanent paper which is less sensitive to ultraviolet light.

Filler grade calcium carbonates have an average particle size of 1.5 to 2.0 microns. The amount of filler used is dependent on the type of paper produced and whether it is coated or uncoated. Some types of paper such as newsprint use no fillers. Uncoated paper for printing may have filler levels ranging from 5% to 15%. Coated papers for magazines usually have filler levels in the 3% to 9% range.

Coating grade carbonates typically have particle sizes in the 0.6 micron to 0.8 micron range, with a top particle size of approximately 4 microns. High brightness (greater than 92 GE) is required. Coatings, of both precipitated and natural carbonates as supplements to the kaolin in the coating mixture, contribute to the whiteness of the paper and improve the ink receptiveness and smoothness. Particle morphology can have a decided impact on the optical properties of the paper, with rhombohedral and scalenohedral particles exhibiting the best performance.

## PUTTY, CAULKS, AND SEALANTS

Calcium carbonate is widely used as a filler for putty, caulks, and sealants due to its low oil absorption, excellent availability, low cost, and whiteness. Calcium carbonates can be used at very high loadings (40% to 50% typical, up to 90% for putty) while maintaining good flow and viscosity. Typical particle sizes are 2 to 3 microns for Grade I to Grade III products with up to 20% retained on a 200 mesh screen. Sealants and caulking compounds generally use the finer grades, while putty uses the coarser Grade III material.

## RUBBER

Calcium carbonate fillers are used in soft rubber goods such as floor coverings and auto mats. Kaolin is the primary filler with calcium carbonate used as a supplement to reduce product cost. Calcium carbonate fillers may also be used in wire and cable coatings, automotive weather stripping, and some footwear applications. Loading levels can be as high as 50% for some low performance rubber products. Grade II or Grade III products are used in low performance rubber products. Grade I fillers, often with surface treated particles, are required for wire and cable coatings.

### CARPET BACKING

Carpet backing is the largest volume application for calcium carbonate where it is used to provide body and weight to the latex rubber, and can be loaded at levels up to 500 parts of filler per 100 parts of latex. Grade II and Grade III products are used, with particle sizes ranging from less than 44 microns to grades as coarse as 10% retained on a 200 mesh screen.

### JOINTING COMPOUNDS

Coarse ground Grade II and Grade III calcium carbonate is used as a filler in drywall jointing compounds. Typical sizes are 90–99% passing 325 mesh and coarser 200 mesh products. Loadings can be as high as 80%. Critical characteristics of the formulated products are colour and application behaviour such as non–sagging and non–cracking.

### ASPHALTIC PRODUCTS

Calcium and magnesium carbonate fillers are used in asphaltic roofing products such as shingles and rolled roofing, asphaltic sealers for driveways, and in automotive undercoatings. Standards in Canada allow for loadings of up to 50% in roofing shingles while in the U.S., loadings up to 60% in shingles are allowed. Coarse Grade III and Grade IV materials are used. The main requirements are controlled particle size, good flow properties, and high bulk density.

### DOLOSTONE FILLERS

Except for asphaltic products, dolostone fillers are not used in North America. This is in contrast to Europe, where finely ground white dolomitic marble fillers are extensively used in paints, plastics and other applications where high whiteness, low oil absorption, and low abrasiveness are required. Possible reasons for the lack of use of dolostone fillers in North America are:

- lack of detailed performance characteristics
- ready availability of calcitic fillers
- tradition
- possible adverse chemical reaction with water to form magnesium sulphate as a result of the reaction of dolomite with sulphur dioxide to form sulphurous acid.

# Building Stone

In recent years the building stone industry has undergone considerable development. The introduction of modern European cutting and polishing technology, the development of new fastening systems and favourable exchange rates have combined to make dimension stone an increasingly attractive building material. While the emphasis has been on granite, the limestone industry has also benefited from the renewed interest in building stone.

Building stone (also known as dimension stone) first became a significant industry in Ontario with the construction of the Welland and Rideau canals between 1824 and 1832. These major projects involved the extensive quarrying of limestone blocks for dams, locks and retaining walls. Many stone masons from Britain and elsewhere were hired for this work, and a lot of them settled permanently in Ontario where they encouraged the continued use of stone in both commercial and residential construction as well as in major public works. Early construction techniques relied on massive stone foundations and thick stone walls for their load–bearing capability; hence, evenly–bedded Paleozoic limestones were most frequently used.

Parks' (1912) report on "Building and Ornamental Stones of Canada" mentions 137 quarries actively producing building stone from Ontario's Paleozoic limestones and dolostones and 19 building stone quarries in the Grenville marble of eastern Ontario. However, by 1912 some former building stone quarries had already switched to the production of crushed stone, as a maturing portland cement industry encouraged the increased use of concrete and cement blocks. Goudge (1933) reported only 14 active Ontario quarries in his report "Canadian Limestones for Building Purposes". In 1986 there were 12 active limestone quarries producing building stone, but no marble quarries except those used for terrazzo and landscaping chips, and white industrial fillers.

The principal limestone building stone producing areas of Ontario are the Bruce Peninsula area around Wiarton and the Niagara Escarpment near Queenston and Thorold. Limestone mill blocks suitable for cut stone were produced by Queenston Quarries at Queenston and by Niagara Cut Stone at a quarry near Thorold. Mill blocks are produced at various locations on the Bruce Peninsula. The Adair Marble quarry (site O–1 in the Owen Sound District chapter, Volume III) of Arriscraft Corporation produces mill blocks which are processed at the company's plant at Cambridge (site CB–14 in the Cambridge District chapter). Thin–bedded limestone suitable for the production of flagstone, copings, sills and ashlar coursing is quarried at a number of small facilities near Wiarton and on Manitoulin Island. Building stone production in eastern Ontario, which had been a major factor in the development of Ontario's limestone industries, has largely disappeared, although mill blocks of black Bobcaygeon Formation limestone are produced at the Cornwall Gravel Company Ltd. quarry at Cornwall (site CW–14 in the Cornwall District chapter, Volume II).

Marble mill blocks were taken from several localities in eastern Ontario in the 1960s, principally the Tatlock and Sharbot Lake areas. Marble mill blocks are no longer produced, with most of the output being in the form of pulverized stone for terrazzo chips and other uses from quarries in the Madoc area. However, Karnuk Marble Industries Inc. in Cornwall does process imported mill blocks in a recently established, European–equipped plant and has conducted some exploratory work for the extraction of mill blocks.

The potential for building stone from Grenville marble in eastern Ontario has been discussed in Verschuren et al., (1985, p.24–34).

## DEFINITIONS OF BUILDING STONE

Building stone is classified as either mill blocks or cut stone. Mill blocks are large rectangular blocks of stone measuring several metres on the side and weighing up to 40 tonnes, though typically 15 to 20 tonnes. Modern processing equipment and the economics of processing generally demand that mill blocks be as large as possible to increase the overall recovery rate. For maximum quarry recovery mill blocks should be at least 2 m x 1 m x 1.3 m and ideally 3 m x 1.3 m x 1.5 m.

Cut stone or finished stone is sawn from mill blocks to specific size specifications. The cut stone panels may range in thickness from 1.5 cm to 20 cm, depending on their use for exterior or interior requirements and the type of sawing equipment used. Cut limestone is now most commonly employed for interior applications, although certain exterior uses are not uncommon. Cut stone may also be used for sills, lintels, steps, coping, etc. Cut marble is employed for both interior and exterior uses. A variety of surface finishes are available for cut stone; limestone is supplied with gang–sawn finish, chat or shot–sawn finish, smooth machine finish, wet cobbed or hand finish, depending on the fineness of finish required. Marble for interior use is generally polished, while that for exterior uses has a sawn, rubbed, or honed finish.

Building stones are defined under a variety of names, depending upon their use and finish. Rectangular blocks of stone up to 30 cm or more in length and bounded by sawn, planed, or planar surfaces and used in walls or building faces are termed "ashlar" or "coursing ashlar". "Split–faced ashlar" has a natural rock face produced by splitting the rock by machine guillotine or other methods along the line of fracture on both sides of the stone. "Rock–faced ashlar" has a natural rock face pitched by hand tooling.

"Even–faced ashlar" uses blocks of equal height for each course, with the blocks of each course being equal or unequal in length. "Random coursed ashlar" uses blocks of differing size and height. Both types of ashlar are well represented in the limestone buildings of Queen's University and the Royal Military College in Kingston.

Ashlar may also have a finish referred to as "pointed face", "hammered face" and "pick face". The terms correspond to the method used to develop a planar face. Pointed ashlar is produced using a pointing chisel, hammered ashlar by the use of a hammer, and pick ashlar by the use of a mason's pick.

Ashlar may also have a sawn face and can be laid up with the bedding surface exposed. In this case it is termed "strataface ashlar" or coursing.

Rubble is a term applied to irregular building stones up to about 30 cm in length. The stones are not regularly rectangular and there is no even coursing.

Flagstone consists of thin beds of stone 2 cm to 8 cm in thickness. "Regular" flagstone is rectangular in shape with sawn or rock face edges. These are used for steps, paths, patios, etc. "Random flagstone" is irregular in shape with rock faces and is commonly used for walks, patios, etc. "Wall flagstone" is thin (0.5 cm to 2.5 cm) natural random flagstone used for interior wall applications. It is a variety of veneer.

Veneer is made from thin slabs of stone from 1.5 cm to 8 cm in thickness and may be even shaped or irregular. It is used as facing stone for buildings, walls, etc. The slabs are set on edge and present their large face to the viewer. New technology for the manufacture of large limestone veneer faces is revitalizing this market. Thin (1 cm to 2 cm thick) smooth–faced limestone veneers are adhesively and/or mechanically bonded to pre–cast concrete panels at the stone dressing plant, and these panels are then placed in position at the building site. The result is a very economic method of construction. An example of this technology is the recently completed county court house in Ottawa which is faced with "Adair Marble", a dolostone produced by Arriscraft Corporation in the Wiarton area.

Other uses of building stone are for copings, steps, sills, hearths, mantles, chimney caps, riprap and armour stone, and monumental stone. Granite is the most common stone used today for monumental stone; limestone is rarely used, and marble only occasionally.

## PROPERTIES OF BUILDING STONE

The physical properties of building stone are important in evaluating the quality of a building stone deposit. Some of the key considerations are:

- geological features such as character of jointing, bedding, uniformity of colour and freedom from intrusion, shear zones, alteration zones and deleterious materials.
- chemical composition, especially as it may affect the weathering properties of the stone.
- petrographic examination to determine the mineralogical composition of the stone and its texture, grain size, alteration and type and character of cementation.
- colour and uniformity of colour, especially over time.
- staining and efflorescence due to deleterious materials such as pyrite and soluble salts.
- absorption and porosity of the rock, which influence the frost resistance of the rock.
- durability and soundness, freeze–thaw resistance and abrasive hardness.
- compressive strength and transverse strength.

## QUARRYING METHODS

Geological features such as bedding, foliation, jointing, rift and grain are very important features to consider in planning a quarry operation. The thickness of the beds largely determines the thickness of mill blocks that can be removed from sedimentary formations. Foliation is frequently present to some degree in marble. The direction, dip, and frequency of joints is of primary importance in quarry development of all stones. Spacing of vertical joints may govern the size of mill blocks which can be removed and if vertical joints are spaced too closely they may render the stone commercially useless for building stone. The directions of easy breaking, rift and grain, should be used in laying out the quarry plan.

There are four main quarrying methods used in Ontario building stone quarries:

1. Hand quarrying
2. Knox method
3. Channelling by drilling and broaching
4. Wire saw method

## HAND QUARRYING

Nearly all the small building stone quarries in Ontario, which produce ashlar, flagstone, sills, coping, steps, etc., are operated by hand quarrying methods. Hand quarrying is employed where the bedding planes are relatively closely spaced, usually from 5 cm to 25 cm apart. Equipment consists of air compressor, drills, crowbars, wedges, chisels, plugs and feathers and in some instances portable stone saws using diamond blades.

The quarries of the Wiarton area quarrying the thin Eramosa Member beds of the Amabel Formation employ portable diamond saws to cut the stone in place in the quarry. The diamond saws have blades of 30 cm to 45 cm in diameter and cuts are made as desired across a quarrying width of 4 to 5 m. The stone is lifted by bars and fork lift trucks.

## KNOX METHOD

The Knox method of quarrying was employed at Queenston Quarries (site NI–4 in the Niagara District chapter, Volume III). The building stone occurs in a ledge 3 to 5 m thick with beds 0.3 to 2 m thick. When a sufficient area had been stripped of the overlying rock, the beds were examined for vertical joints which may occur 3 to 15 m apart. The Knox method requires three free faces and a bedding plane on the bottom. The free quarry face is established at right angles to the jointing by removal of a key block from one joint to the other. The block to be quarried is then bounded by the free quarry face on one side and by the two joints at either end, or by one joint and an open end where the adjacent block has been removed. Quarry blocks are split off parallel to the free face by making a back–wall cut parallel to the free face at a distance of 3 to 3.5 m from the face. A series of 3.5 cm holes are drilled, 3.5 to 4 m deep, on 0.6 m centres in a line parallel to the quarry face at the required distance from the face. Jackhammers or Joy wagon drills were used for drilling. The line of holes was from 3 to 15 m long depending on the joint spacing.

The drill holes are reamed by a Knox bit which grooves the hole on each side in the direction along which the break is to be made. The holes are loaded lightly with black powder and fired with caps. An air space is left in each hole between the charge and the tamping to allow the force of the explosion to be exerted on a relatively side surface. Where there are horizontal bedding planes in the block to be quarried, a charge is placed for each bed.

The quarry block is separated from the solid ledge by the blast and then drilled and split by plug and feather into random mill blocks. Horizontal holes may be drilled to lift the beds where necessary. Blocks are handled by derricks.

## CHANNELLING BY DRILLING AND BROACHING

The method of channelling and broaching using quarry bars was formerly employed in some limestone quarries in Ontario. The method involves cutting out the block by closely spaced drill holes and breaking out the web of rock between the holes by a broaching tool. Two to four drills are mounted on each quarry bar and clamped to drill at the required angle. The drills can then be moved along the bar to drill a series of parallel holes. The channelling is usually carried out on the four vertical sides of the block. If necessary horizontal holes can be drilled to break out the block at the base. Mill blocks are handled by a derrick.

## WIRE SAW METHOD

The wire saw was formerly used to quarry marble at the Tatlock quarry of Omega Tile and Terrazzo Ltd. Sawing was done by a three–strand steel wire 5 to 6 mm in diameter, using sand or carborundum as the abrasive. Modern wire saws use a diamond wire. Wire saws are also used in stone dressing plants for cutting stone.

Recent technological advances in drilling methods include the use of jet cutting and water assisted jet cutting torches and the use of multiple circular saws. Quarrying methods for building stone, however, will largely continue to rely on a considerable amount of hand labour in order to minimize breakage of the mill blocks.

## STONE DRESSING

In many of the small limestone quarries the stone is dressed by hand cutting, using hammers and chisels for cutting and shaping the stone. In several quarries split faced ashlar is made by splitting the stone by guillotine, a hydraulic cutting machine whose cutting edge consists of a series of 2.5 cm teeth which will accommodate themselves to irregularities in the stone. Portable diamond saws are used in some limestone quarries for cutting stone to desired sizes.

Mill blocks are cut by gang saws using either steel blades with silica sand as the abrasive or diamond set saws. Diamond saws are considerably faster. Modern gang saws may have up to 120 blades and can be operated in either the horizontal or vertical direction in a fully automatic mode.

Stone cutting is also carried out by circular diamond saws and by wire saws. Planing machines are employed for giving the stone a smooth finish, making special shapes and mouldings. Polishing of marble is done on rubbing and polishing beds. Modern surfacing and polishing equipment consists of multiple–head (up to 8) grinders and polishers. This equipment is often fully automated and allows for the assembly line production of stone pieces.

For detailed information on a modern processing plant, refer to the description of the Karnuk Marble Industries Inc. plant (site CW–28) in the Cornwall District chapter, Volume II.

# Pulverized Stone and Stone Chips

## INTRODUCTION

A relatively small but specialized market has persisted in Ontario for many years for distinctly coloured marble and limestone chips and, particularly, for white marble chips. Markets for these products include terrazzo, landscaping and gardening, exposed aggregate in precast concrete panels, in sulphite pulp production, agricultural limestone, stucco, cultured marble, tile grout, poultry grit, animal feed additives, and sand traps for golf courses.

White Grenville marble of high chemical purity, either calcitic or dolomitic, is preferred for most uses. Terrazzo chips, however, are required in a variety of colours and are also derived from certain coloured Paleozoic limestones.

## TERRAZZO CHIPS

Marble and limestone chips in various sizes and colours are used as coarse aggregates in floors and window sills, particularly in offices and institutional buildings. The chips are bonded by a fine-grained neutral or coloured cementing matrix, and are generally cast in place. After hardening, the exposed surface is ground and polished by portable electric equipment. The industry is represented in Canada by The Terrazzo, Tile and Marble Association of Canada with offices in Toronto.

The physical properties of a number of terrazzo aggregates from the Madoc area of Eastern Ontario have been favourably compared with imported ones by Hewitt (1964). Colour should be uniform, texture should be fine-grained and massive, absorption should be low, and abrasive hardness should be sufficient to withstand whatever wear is anticipated. While siliceous minerals improve the abrasive hardness of a marble, they are undesirable because of the difficulty of getting a uniform polish over the entire chip plus the increased polishing costs.

## WHITE MARBLE CHIPS

Except for finely-ground white calcitic marble, which enjoys a substantial market in a variety of industrial filler applications, coarser marble products have a limited market in a variety of uses. Although good whiteness is generally essential, coarser marble products can be either calcitic or dolomitic in composition. Some of the principal uses are outlined as follows.

### PULP AND PAPER

Blocks with diameters in the range of 20 cm to 35 cm, either calcitic or dolomitic in composition, are used in the Jensen tower system for making the sulphurous acid-bisulphite solution necessary in the production of sulphite wood pulp. The solution is made by bubbling sulphur dioxide gas through water towers packed with high-purity lump limestone or dolostone.

Although whiteness is desirable, chemical purity is more important. If limestone is used, the lime content should exceed 53 percent, the magnesia content should be less than 1.5 percent, combined silica, alumina and iron should be less than 1.5 percent, and organic matter less than 0.5 percent. If dolostone is used, the calcium carbonate content should be 54–59 percent, magnesium carbonate 35–44 percent, iron and alumina not more than 1 percent, and total insolubles not more than 2 percent (Hewitt, 1960, p.16).

### LANDSCAPING AND GARDENING

White marble chips are enjoying a strong demand for decorative purposes in various gardening and landscaping uses, such as for surface dressing on driveways and garden paths, and as accent features in planters and gardens. At the retail level they are sold either in plastic bags or in bulk at most plant and garden nurseries.

Specifications are not critical. The stone can be either calcitic or dolomitic and not necessarily of high chemical purity as long as it is durable and of uniform whiteness. Coarse-grained marbles, although sometimes more friable, may be preferred because of the lustre on cleavage faces. Coloured impurities either as disseminated dark minerals, off-colour chips, or as foreign rock fragments should be minimal. Preferred chip size is −1 1/4 in. +3/4 in. and to a lesser extent −3/4 in. +3/8 in. A superior product is produced by washing away any fines adhering to the chips after crushing and screening.

### POULTRY GRIT

A substantial market exists for poultry grit, and sand for tropical fish tanks, etc. Calcitic marble has generally been preferred, but dolomitic material and other less soluble rocks are sometimes used. At least three grit sizes are in demand: −3/16 in. +1/8 in., −6 mesh +12 mesh and −12 mesh +40 mesh.

### STUCCO, CULTURED MARBLE, TILE GROUT

For these markets, both calcitic and dolomitic marbles are suitable. Whiteness and freedom from specking is essential. Products are generally required to be ground to about 200 mesh.

### EXPOSED PRECAST AGGREGATE

White marble chips with similar specifications to gardening and landscaping stone are used in precast concrete panels in the construction of institutional buildings. The chips are normally only lightly imbedded in the concrete so that their exposed surfaces give an aesthetically pleasing exterior wall surface.

In addition to the specifications previously detailed, the chips should be free from discolouring impurities such as iron and sulphide minerals which might stain the surface through subsequent weathering.

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# Part 4 — Production, Economics and Markets for Limestone Commodities

# Limestone Aggregates

## DEMAND

Construction and related uses account for the majority of crushed limestone demand, generally over 90% of the total. Reliable data on the distribution of demand within construction–related end uses are difficult to obtain. Data derived from analysis of production reports to the Ontario Ministry of Natural Resources indicate that significant shifts in the volume and value of production do occur. These shifts are principally due to the effects of the business cycle on construction activity. The data showing end use demand in recent years are provided in Figure 4.1 and Figure 4.2 and show the following:

- Ontario crushed stone production has remained relatively stable from 1980 to 1985, but with significant declines during the 1982–1983 recession;
- The distribution of stone demand by end use has also remained relatively constant, except for the influence of the business cycle. During the 1982–1983 period the percentage of stone consumed in road–related end uses increased significantly. Other end uses declined during this period. This shift in end use consumption patterns reflects the steady demand for road building aggregates, versus the more vulnerable demand for other uses such as non– residential construction.

On a regional basis there is some difference between Eastern and Central Ontario in terms of the demand for crushed limestone. Figure 4.3 illustrates 1985 demand patterns for stone. As can be seen, asphalt and concrete aggregate are more important products in Eastern Ontario than in Central Ontario. However, these differences may be accounted for by reporting errors and incomplete data. Overall, regional differences in end use distribution patterns are believed to be slight.

Approximately 50% of the road building aggregate used in Ontario is crushed stone, the balance being gravel and crushed gravel. Most of the crushed aggregate is consumed as Granular A, asphaltic hot mix and concrete aggregate material. Very little crushed limestone in Ontario is used as sub–base. In recent years there has been an increase in the use of crushed limestone in place of sand and gravel for road building aggregate. This results from cost and availability problems associated with sand and gravel production in certain parts of the Province as well as substitution of HL4 crushed limestone in place of HL3 crushed gravel for certain heavy traffic highway applications.

Imports and exports of crushed limestone vary considerably from year to year. The major importing centres are in southwestern Ontario, principally Sarnia, Windsor and Kingsville. Imports are almost exclusively by vessel from the large quarries in Michigan operated by the steel companies and the Standard Aggregates Inc. Mantoulin Island quarry. Imports of crushed limestone have averaged 590,000 tonnes per year, but have fluctuated from

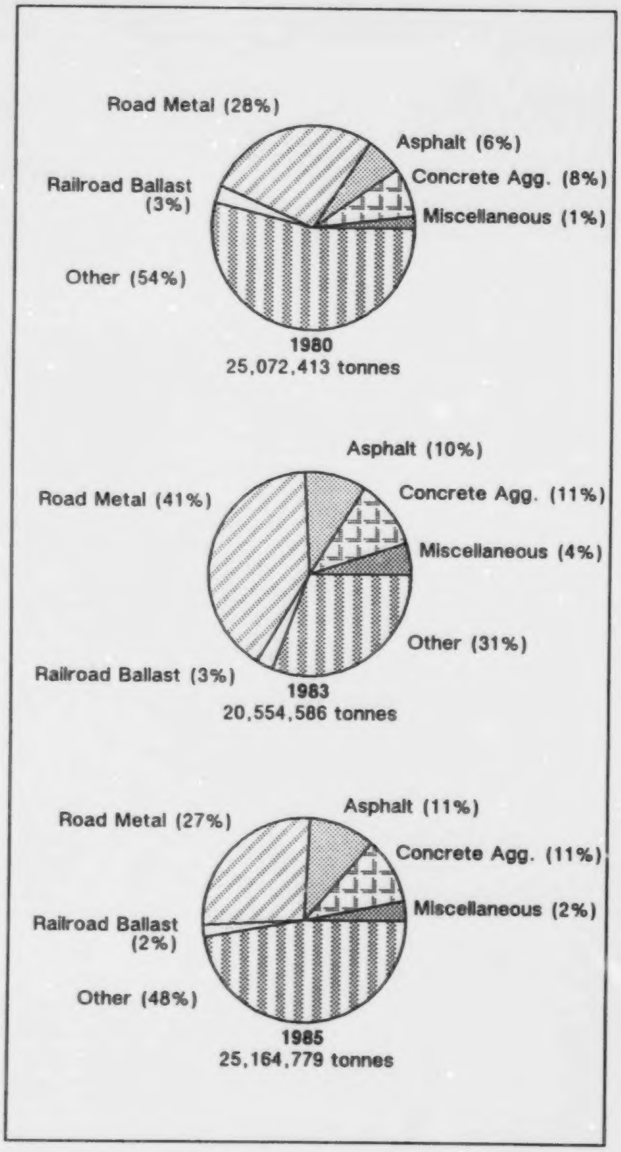


**Figure 4.1. ONTARIO STONE PRODUCTION BY USE.** *Data source: "Ontario Mineral Score", Ontario Ministry of Northern Development and Mines, 1981-1986 and Canadian Minerals Yearbook, 1986.*

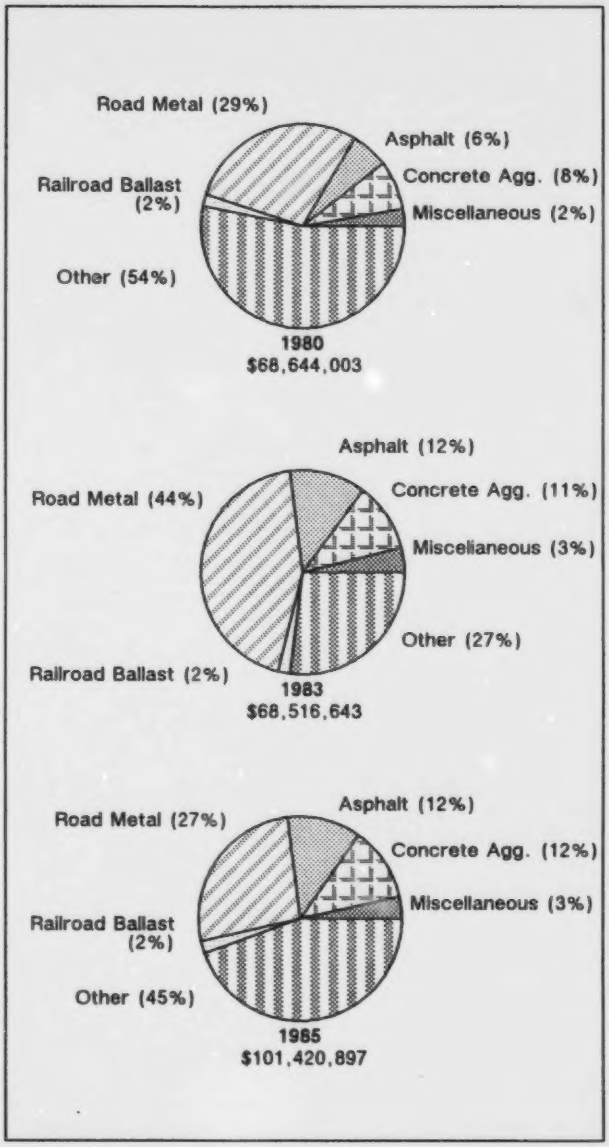


**Figure 4.2. VALUE OF ONTARIO STONE PRODUCTION BY USE.** *Data source: "Ontario Mineral Score", Ontario Ministry of Northern Development and Mines, 1981-1986 and Canadian Minerals Yearbook, 1986.*

a low of 451,000 tonnes to a high of 717,000 tonnes during the 1982-1985 period.

Exports of crushed limestone and dolostone have been from only two centres - Port Colborne Quarries Ltd. in Pt. Colborne, and Standard Aggregates Inc. on Manitoulin Island. Most of the stone has been exported for construction related uses, although the Manitoulin quarry has been successful in penetrating the US market for metallurgical stone. Data on imports and exports of crushed limestone are provided in Table 4.1.

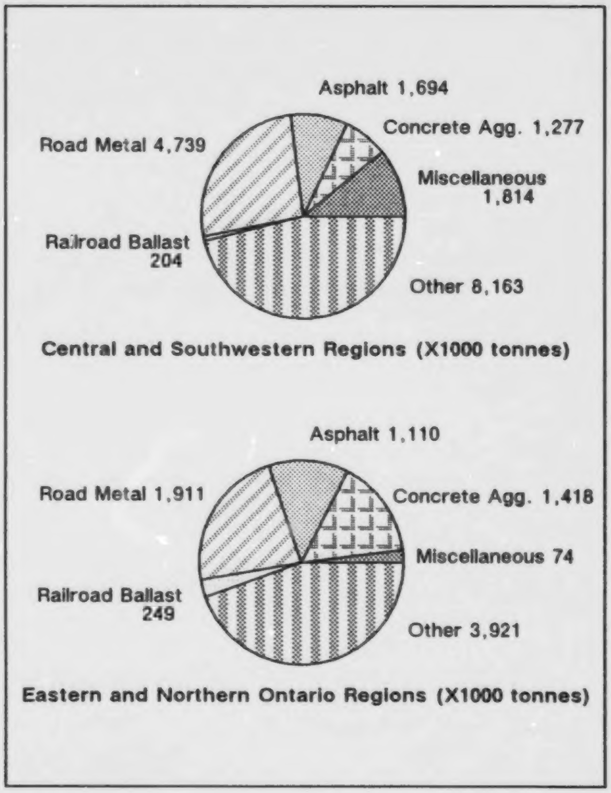


**Figure 4.3. 1985 STONE PRODUCTION BY USE.** *Source: derived from Ontario Mineral Score data.*

Data on total Canadian and US demand for crushed limestone are provided in Figure 4.4 and Figure 4.5. As can be seen, the distribution by end use is approximately the same in both countries.

Demand for crushed limestone for all uses is expected to increase in line with road building and construction activity. A simple linear regression model of demand is provided in Figure 4.6. This forecast predicts crushed limestone production will increase from the 1985 level of approximately 45 million tonnes to a level of approximately 65 million tonnes in 1996. This represents an average annual increase of 3.4%. Figure 4.7 provides a similar forecast for sand and gravel production. As can be seen, most of the increase in crushed stone production is attributable to the decline in sand and gravel production. Forecasts of limestone demand for chemical and metallurgical uses indicate relatively little change. Thus, one can conclude that the increased

**Table 4.1. TRANS-BORDER MOVEMENTS OF STONE FROM ONTARIO.**

(tonnes)

| | 1982 | | 1983 | | 1984 | | 1985 | |
|---|---|---|---|---|---|---|---|---|
| | Agg. | Chem/Met. | Agg. | Chem/Met. | Agg. | Chem/Met. | Agg. | Chem/Met. |
| Cdn.-US ports | 26,308 | 203,157 | 518,028 | 299,198 | 333,558 | 163,400 | 821,775 | 357,831 |
| US-Cdn. ports | 451,059 | 893,917 | 683,068 | 946,150 | 512,544 | 1,127,329 | 717,271 | 1,052,579 |

*Source: Statistics Canada, 1986*

production of crushed limestone will be primarily attributable to the increased demand for construction– related aggregate. More detailed forecasts of the demand for construction aggregates have been prepared in conjunction with assessments of the supply of aggregate materials. These forecasts have been prepared on a provincial and on a regional basis.

- Proctor and Redfern Ltd. and Gartner Lee Associates Ltd. prepared several studies of aggregate supply and demand in the 1970s for various Ontario regions. These studies indicated that supplies of crushed stone from currently licensed quarries would be exhausted shortly after the year 2000 in many regions of the Province.
- Forecasts of aggregate demand in the Toronto, London, Windsor and Sarnia areas (Peat, Marwick and Partners and M.M. Dillon Ltd. 1980) predicted demand for crushed stone would exceed then currently licensed reserves in the early 1990s (London area) and approximately 2000 (Toronto area). Supply in the Windsor and Sarnia areas was already deficient.

All of the studies indicated that supplies of crushed stone would have to be obtained from more distant sources at considerably increased costs or that new quarries would have to be licensed within the regions under study if transportation costs were to be minimized.

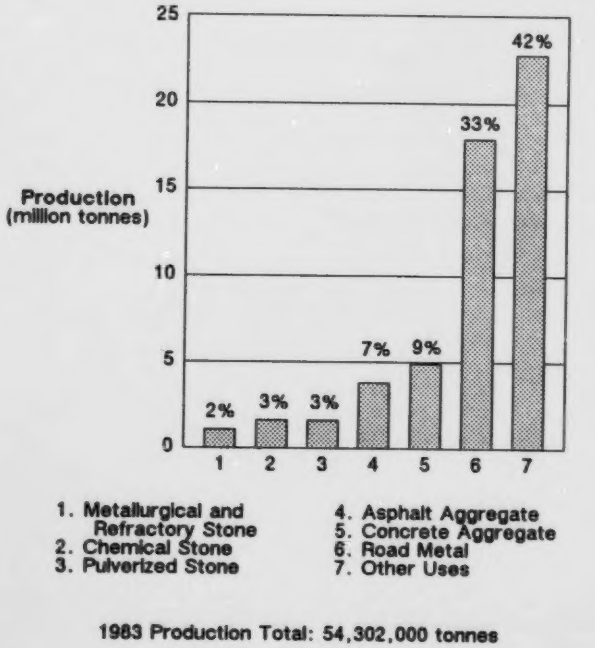


**Figure 4.4. CANADIAN LIMESTONE AND MARBLE PRODUCTION.** *Source: Canadian Minerals Yearbook, 1986.*

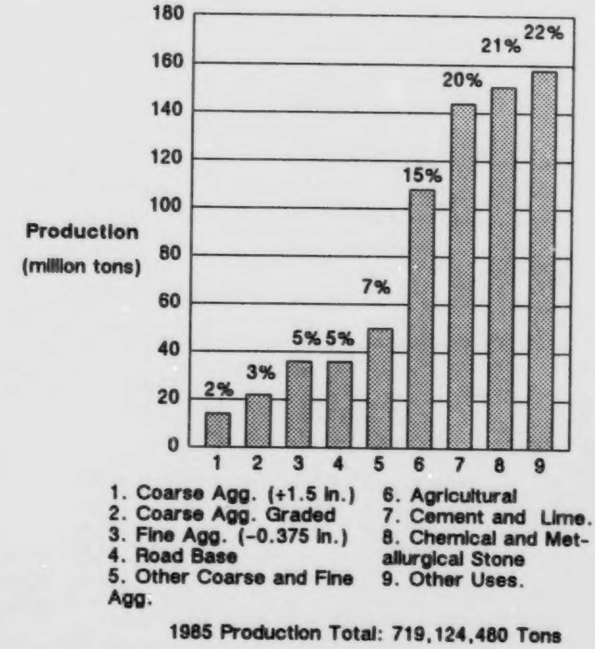


**Figure 4.5. US LIMESTONE, DOLOSTONE AND MARBLE PRODUCTION.** *Source: US Bureau of Mines Minerals Yearbook, 1985.*

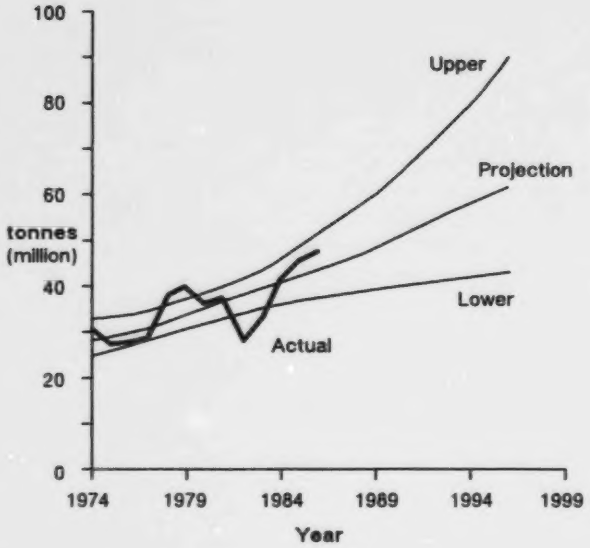


**Figure 4.6.** ONTARIO STONE PRODUCTION FORECAST, SHOWING ACTUAL DATA, PROJECTION AND 95% LIMITS.

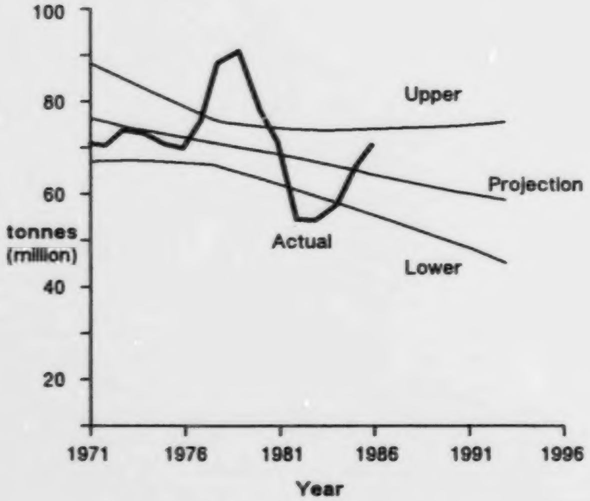


**Figure 4.7.** ONTARIO SAND AND GRAVEL PRODUCTION FORECAST, SHOWING ACTUAL DATA, PROJECTION AND 95% LIMITS.

## AGGREGATE SUPPLY

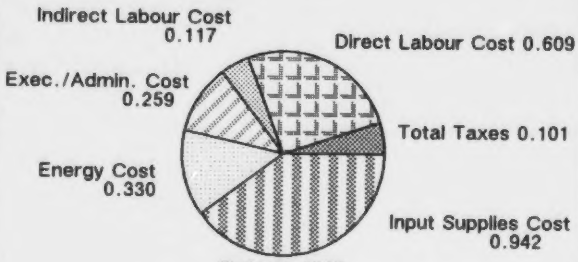
Aggregate supply must be considered in terms of the quality of the available material, the quantity of the available material, and the costs of the material. Aggregates which are available only at very high prices should not be considered to be part of the current supply base. Several studies of the supply of aggregate materials have pointed out that aggregate shortages can be expected to develop around the year 2000 in most regions of the Province due to exhaustion of currently licensed reserves. In response to these concerns, the Government of Ontario has implemented new land use planning guidelines designed to protect aggregate sources from incompatible uses which would prevent future utilization. The Mineral Aggregate Resources Policy Statement is designed to balance the need for aggregate against other land uses within the local planning framework.

Possible new sources of supply of coarse limestone aggregate include Manitoulin Island and some of the quarries operated by the current cement producers such as St. Lawrence Cement Inc. at Colborne and Lake Ontario Cement Ltd. at Picton. The General Chemical Canada Ltd. quarry at Amherstburg is also a possible major source of aggregate. To some extent, these sources have been developed. For example, Standard Aggregates' Manitoulin quarry has displaced a considerable volume of imported stone in the Sarnia– Windsor market area. These new sources, however, will not meet requirements of all products due to either chemical or physical limitations of the stone or high delivered costs.

## PRODUCTION COSTS

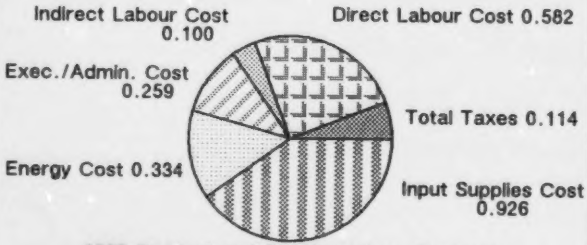
Production costs for crushed limestone are shown in Figure 4.8. In 1985 total costs of production averaged \$2.36/tonne. Of this cost, 40% was accounted for by items such as explosives, spare parts, etc. Energy, principally diesel fuel and electricity, accounted for 14% of costs, while direct and indirect labour accounted for 31% of costs. During the 1980–1985 period the fastest rising costs have been for energy and direct labour. Other costs have not changed significantly.

On a regional basis one can note differences in production costs. These are shown in Figure 4.9. The differences are believed to originate with the differences in the relative size of quarry operations in Eastern and Northern Ontario versus those in Central and Southwestern Ontario; the average size of operation being considerably larger in the Central and Southwest regions. In terms of the distribution of costs there are relatively few differences between the regions except for labour, with Eastern and Northern Ontario having a significantly higher labour cost per tonne. On an overall basis the Eastern and Northern region had a production cost of \$2.46 per tonne, versus a cost of \$2.32 per tonne for the Central and Southwest region.

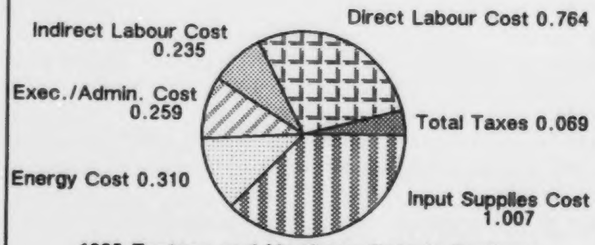


Ontario 1985
(Dollars per tonne)

**Figure 4.8. COSTS OF STONE PRODUCTION, ONTARIO 1985.** *Derived from "Ontario Mineral Score", Ontario Ministry of Northern Development and Mines, 1986.*



1985 Central and Southwestern Regions
(Dollars per tonne)



1985 Eastern and Northern Ontario Regions
(Dollars per tonne)

**Figure 4.9. COSTS OF STONE PRODUCTION BY REGION - 1985.** *Derived from "Ontario Mineral Score", Ontario Ministry of Northern Development and Mines, 1986.*

## PRICES

There are no standard prices for crushed limestone. In addition to supply and demand factors, prices are determined regionally, or even locally, by production and transportation costs, by the degree of processing required for a particular end use and by the quantity of material required for a particular project. Transportation costs are particularly significant as the choice between two competing sources of supply is based on the delivered price of the stone.

Some guidance as to prices can be obtained from reference to Statistics Canada data which shows the following for Canadian limestone prices in 1983:

| End Use | 1983 Price/Tonne |
|---|---|
| Artificial Stone | $38.00 |
| Roofing granules | 9.87 |
| Poultry grit | 19.12 |
| Stucco dash | 28.00 |
| Rubble & riprap | 5.00 |
| Concrete aggregate | 3.79 |
| Asphalt aggregate | 4.02 |
| Road metal | 3.56 |
| Railroad ballast | 3.54 |
| Other uses | 3.33 |
| Average value, all uses including chemical & metallurgical | 4.02 |

As can be seen, the lower volume, more highly processed materials attract prices considerably in excess of those for other materials. Prices are expected to increase in line with production costs and the costs for quarry rehabilitation and taxes.

## TRANSPORTATION COSTS

Transportation costs are a significant factor in determining the delivered price of stone and the markets available to a particular producer. Where access to cheap and efficient transportation is available, crushed stone can be delivered to sites several thousand kilometres distant at prices competitive with nearby sources. A good example of this occurs in the Strait of Canso area in Nova Scotia, where the local producer has been able to ship stone to points as far as Houston, Texas and to the Caribbean due to ready access to deep water shipping facilities. In Ontario, aggregate is moved by truck, ship and rail. Truck is by far the most important mode. The Aggregate Producers Association of Ontario estimates that over 2.5 million deliveries to Metro Toronto were made by truck in 1986. Water–borne movements of stone are relatively minor at present but are expected to increase in significance during the next decade. Rail transport of stone is rapidly declining in importance. It represents less than 5% of the total tonnage movement.

Trucking is expected to remain the dominant transportation mode. It offers the greatest flexibility to both producer and consumer in terms of frequency of delivery and average load size. It also requires the least amount of fixed investment for loading and unloading facilities and the least amount of double handling of the stone. For most quarry operators, trucking is the only possible transportation method. Representative truck operating costs as of mid–1986 for typical Ontario bulk operators are shown in Table 4.2. It is readily seen that transportation charges can rapidly exceed the FOB cost of the stone. In general, it is difficult for a quarry operator to be successful in selling to markets beyond a radius of 100 km from his plant.

Shipping costs by water are considerably below those for trucking. For example, typical 1985 costs for shipping 20,000 tonne loads from Manitoulin Island to various Ontario ports, depending on the line used, were:

| | |
|---|---|
| Sarnia | $2.73 – $3.35 per tonne |
| Windsor | $2.99 – $4.10 per tonne |
| Sault Ste. Marie | $2.63 – $4.50 per tonne |
| Nanticoke | $3.99 – $6.00 per tonne |

These rates are for self–unloading vessels delivering full loads; partial loads and drop–offs adding considerably to the freight charges. Water–borne movement of stone is generally not practical from the upper lakes to Lake Ontario ports due to the tolls on the Welland Canal and the extra transit time. Nevertheless, should trucking rates continue to escalate, and should the availability of nearby aggregate sources diminish, movement of stone from locations such as Manitoulin Island to southern Ontario ports must be considered a real possibility.

Rail shipping, while cheaper than trucking, is very inflexible. It requires very large volumes of stone and a large investment in terminal facilities at either end to be economic. Very few aggregate producers generate the required volumes to justify the expense. In addition, the stone must generally be moved by truck to its final destination. The extra handling adds considerably to the delivered cost of the stone.

## TECHNOLOGICAL DEVELOPMENTS

Technological developments affecting the demand for aggregate include the following:

- Increased recycling of asphaltic hot mix. Currently about 9% of asphalt is recycled. This is expected to increase in the coming decade and to reduce the demand for Granular A and HL3 and HL4 material.
- Development of longer lasting asphaltic mixes using new additives such as sulphur, rubber, and other compounds. These mixtures are currently only in the test stage but show promise in substantially increasing the life of pavement.
- Increased use of aggregate substitutes such as blast furnace slag and nickel slag. These materials are currently being used as aggregate in road building, as concrete aggregate and as railroad ballast. It is expected supply will not increase and may even decrease due to a long–term reduction in blast furnace iron production and nickel production.
- Increased use of high alkali cements. This could create problems due to excessive sulphate expansion of concretes using alkali reactive aggregates. Many Ontario aggregates are not suitable for use in high alkali cements and significant shortages of suitable aggregates could result if higher alkali cements came into common use.

**Table 4.2. ONTARIO BULK TRUCK OPERATING COSTS, (MID–1986).**

| Type of truck | Typical payload | Annual distance (km) | Cost/km | | Cost/Tonne.km | |
|---|---|---|---|---|---|---|
| | | | Paved roads | Gravel roads | Paved roads | Gravel roads |
| 5–axle semi trailer | 22.6 t | 80,000 | $1.422 | $1.662 | $0.0629 | $0.0735 |
| | | 160,000 | $1.201 | $1.441 | $0.0531 | $0.0638 |
| | | 240,000 | $1.128 | $1.368 | $0.0499 | $0.0605 |
| 7–axle semi trailer with pup | 42.9 t | 80,000 | $1.655 | $1.895 | $0.0386 | $0.0442 |
| | | 160,000 | $1.378 | $1.621 | $0.0321 | $0.0378 |
| | | 240,000 | $1.284 | $1.527 | $0.0299 | $0.0356 |

*Source: "Operating costs of trucks in Canada", Transport Canada, 1986.*

# Cement

Ontario has five companies operating a total of seven portland cement manufacturing plants with a total installed capacity of 6.257 million tonnes of clinker. In addition, two slag cement manufacturing plants are operated in the province.

The Ontario portland cement industry is characterized by a high degree of both vertical and horizontal integration. Vertical integration refers to the ownership of aggregate, cement, ready–mix, concrete products, and construction companies within one corporate organization. Horizontal integration refers to the merging of one cement company with another. Horizontal and vertical integration usually have the effect of increasing economies of scale and thus reducing unit costs and increasing marketing and financing efficiencies. Vertical and horizontal integration may also have the effect of reducing competition and thus limiting price variations between competitors.

Vertical and horizontal integration in the cement industry has been prompted by the very high capital cost of new plant construction, high financing costs, the slow growth of the market, and the relatively low level of capacity utilization. Growth by acquisition is thus seen by the producers as the cheapest route to expansion and increases in cement plant operating rates. This is especially true in the case of expansion into the US market. Each of the major Ontario cement producers has significant operations in the US which receive clinker and/or finished cement from Ontario plants.

Ontario's cement industry produced 4,043,742 tonnes in 1985 and 4,843,000 tonnes in 1986. The value of production was $265 million in 1985 and $329 million in 1986. The industry directly employed 1,060 persons in 1985, and an unknown number of persons in associated industries such as ready–mix and concrete products manufacture, and haulage.

The Ontario cement operations are listed in Table 4.3. Significant characteristics of each of these companies are briefly noted in the following section.

## ONTARIO CEMENT PRODUCERS

*Lafarge Canada Inc.* operates two cement plants in Ontario, at Bath and Woodstock. The Bath plant has a single dry process kiln with a capacity for 943,000 tonnes of clinker. The Woodstock plant has two wet process kilns with a total clinker capacity of 505,000 tonnes. Both

**Table 4.3. ONTARIO CEMENT PRODUCERS, 1987.**

| Company | Plant Location | Process & Fuel type | No. of kilns | Capacity<br>Clinker ('000 tpy) | Capacity<br>Grinding ('000 tpy) |
|---|---|---|---|---|---|
| | | **Portland Cement Producers** | | | |
| Lafarge Canada | Bath | Dry, Coal, Oil, Gas preheater | 1 | 943 | 1,000 |
| | Woodstock | Wet, Coal, Gas | 2 | 505 | 535 |
| Federal White Cement | Woodstock | Dry, Oil | 1 | 100 | 100 |
| Lake Ontario Cement | Picton | Dry, Dry with preheater, Coal, Oil, Gas | 4* | 1,419 | 744 |
| St. Lawrence Cement | Clarkson | 2 Wet, Dry with preheater, Coal, Oil, Gas | 3 | 1,700 | 2,400 |
| St. Marys Cement | Bowmanville | Wet, Coal | 2 | 600 | 790 |
| | St. Marys | Dry, Coal preheater, | 1 | 700 | 800 |
| | | Wet, Coal, Oil | 2* | 290 | |
| | | **Slag Cement Producers** | | | |
| Reiss Lime | Spragge | | | | 200 |
| Standard Slag Cement Co. | Fruitland | | | | 200 |

**On standby, not normally used.*
*Source: Canadian Minerals Yearbook, 1986, company contact.*

plants obtain stone from quarries on site, the other raw materials being purchased.

Lafarge Canada is the largest cement company in Canada and the only company with cement production facilities in all regions of the country. Through its US operations, General Portland Cement, Lafarge Canada is the largest cement producer in North America. In Ontario, Lafarge Canada is integrated vertically through the ownership of Standard Industries Limited (aggregates, ready–mix, concrete blocks), Permanent Concrete (ready–mix, pre–cast concrete products, concrete blocks), Canfarge Limited (construction), and Richvale Block and Ready–Mix and McCord Co. (concrete block, ready–mix). The company is also involved in the reinforcing and structural steel business through its ownership of Francon Limited.

Lafarge Canada was formed as a result of the merger of the Canada Cement Company Ltd. and Lafarge Coppee S.A., a large French cement producer. The majority ownership of Lafarge Canada is held by Lafarge Coppee.

*St. Lawrence Cement Inc.* operates the largest cement plant in Canada at Clarkson (Mississauga), Ontario, with a total clinker capacity of 1.7 million tonnes from three kilns (two wet process and one dry process). Stone for the kilns is brought by boat from a quarry at Ogden Point, approximately 160 km east of Clarkson on the north shore of Lake Ontario.

St. Lawrence Cement is vertically integrated through its ownership of Dufferin Aggregates (aggregates), Dufferin Construction (construction), Dufferin Concrete Products (concrete blocks, ready–mix, pre–cast and pre–stressed concrete products), Boehmers Concrete (ready–mix), Custom Concrete (ready– mix, aggregates, concrete products), and Peninsula Ready–Mix & Supplies (ready– mix, concrete products), and other operations in the United States. The company is controlled by the Swiss–based Holderbank Financiere group.

*Lake Ontario Cement Ltd.* operates a plant and quarry at Picton on Lake Ontario. The plant has a clinker capacity of 1.419 million tonnes from 4 dry process kilns, although only two generally operate. The two operating kilns have a rated capacity of 4,000 tonnes per day. The controlling interest in the company has recently been purchased by Societe des Ciments Francais of France, that country's second largest cement producer.

Lake Ontario Cement is broadly diversified with interests in aggregate production (United Aggregates Ltd. and Maitland Concrete), ready–mix concrete and concrete block production (Premier Concrete, Primeau Argo, KVN Concrete, and Maitland Concrete), concrete products (Bestpipe, Duracon, Utility Vault, Soil Protection Systems), construction (KVN Construction), and cement chemicals (Euclid Chemical Canada). The company operates cement manufacturing and grinding plants in New York and Michigan in the United States.

*St. Marys Cement Company* is a privately held, Canadian–controlled company and operates two cement plants in Ontario. The Bowmanville wet process plant has two kilns with a total annual clinker capacity of 600,000 tonnes, while the St. Marys operation has a newly constructed (1981) single–kiln dry process plant and a two–kiln wet process plant. The latter plant is on stand–by and does not generally operate. Total annual capacity for the St. Marys plants is 1,590,000 tonnes. Stone for the plants is obtained from quarries on site. At the time of printing the company had announced an expansion of the Bowmanville plant.

St. Marys Cement is vertically integrated through its ownership of Canada Building Materials (ready–mix, concrete products), Pre–Con Company (pre– stressed and pre–cast concrete products and construction), Dominion Building Materials (ready–mix), Hancock Sand & Gravel (aggregates), and Hutton Transport Ltd. (bulk cement transportation). The company also owns cement grinding plants in the United States.

*Federal White Cement Limited*, a privately owned company, operates a white portland cement plant at Woodstock adjacent to the Lafarge Canada plant. The Federal White Cement plant was designed and constructed with the assistance of Lafarge Canada and has a kiln capacity of 100,000 tonnes per year. Stone for the plant is purchased from the Lafarge Canada quarry at Woodstock, or the nearby quarries of BeachviLime Ltd.

*Reiss Lime Ltd.* has recently started up a slag cement plant at Spragge, Ontario on the north shore of Lake Huron, with a capacity of 200,000 tonnes. Production is mainly used in backfill for the mines in Sudbury. Raw material for the plant is obtained from Algoma Steel in Sault Ste. Marie where the slag is crushed to minus 25mm. Reiss Lime Ltd. is 50% owned by Reiss Lime Inc. of the United States and 50% by Denison Mines Ltd. of Toronto.

*Standard Slag Cement Co.*, a joint venture of Lafarge Canada, Koppers Co., and Steetley Industries Ltd., produces slag cement, slag aggregate, and expanded slag in Fruitland, near Hamilton from steel slag. The capacity of the plant is approximately 200,000 tonnes per year of slag cement.

## ONTARIO CEMENT PRODUCTION

Ontario is the centre of cement production in Canada, accounting for 40% of clinker production capacity and 40% of cement production. The province is geographically situated to take advantage of the nearby US market. Trends in the production of cement in Ontario are illustrated in Figure 4.10. 1986 production totalled 4,843,000 tonnes with a value of $329 million or $70.66 per tonne. From 1950 through 1986, cement production in Ontario increased at an average annual rate of 4.27%, and the value of that production increased at an average annual rate of 8.79%. In constant 1986 dollars, however, the value of cement production increased at a rate of only 4.01% during the 1950 – 1986 period. The price received per tonne of production has declined slightly from 1950 through 1986 in terms of constant 1971 dollars from $23.70 in 1950 to $20.64 in 1986. Some of these trends are illustrated in Figure 4.11.

Exports represent a significant proportion of Ontario cement production, mostly destined for the US operations of the Ontario cement companies. Each of the Ontario portland cement producers (except for Federal White Cement) has clinker grinding and/or cement terminal facilities in the United States. In almost all cases these facilities are readily accessible by water transport from Ontario.

Canadian and specifically Ontario cement producers have historically operated at low levels of capacity utilization. The 1960s and early 1970s were periods of rapid expansion in Ontario cement production capacity, as was the late 1970s as the economy experienced rapid growth. Current Ontario clinker capacity is approximately 6,257,000 tonnes, while grinding capacity is approximately 6,270,000 tonnes. These data should be compared to 1985 and 1986 production of 4,043,742 tonnes and 4,843,000 tonnes respectively, indicating operating rates of 64.6% and 77.4% for 1985 and 1986. Operating rate data for Canada indicate that cement plant capacity utilization has ranged from a high of 83% in 1977 to a low of 46% in 1983, and was 57% in 1985. By way of contrast, US finished cement plant operating rates in 1985 and 1986 were 73.0% and 76.0% respectively. Clinker production capacity utilization was 77% in 1985 and 85% in 1986. Operating rates for both finished cement production and clinker production have consistently been above operating rates in Canada and Ontario for the past decade. Little change in this relationship is expected during the next several years.

## CEMENT DEMAND

Demand for cement is a function of construction activity. Cement is used in all forms of construction but is a more prominent building material in commercial and engineering construction work. Table 4.4 illustrates construction activity in Ontario and the relative importance of the various types of construction activity. Figure 4.12 plots cement production ($ value) as a percentage of construction materials costs. As can be seen, cement represents

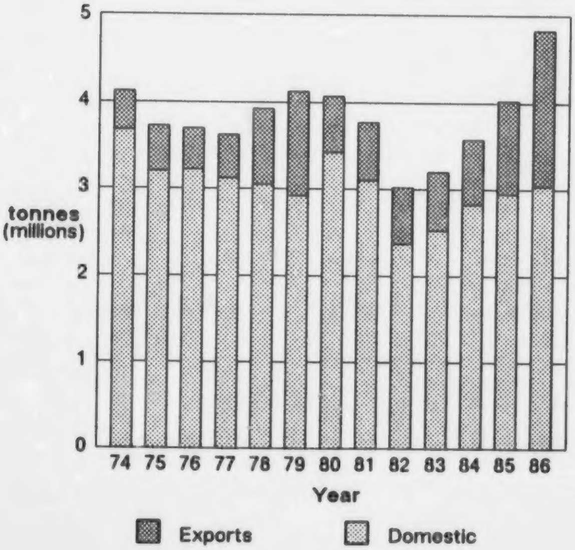


**Figure 4.10. ONTARIO CEMENT, DOMESTIC AND EXPORT PRODUCTION.** *Derived from data "Ontario Mineral Score", Ontario Ministry of Northern Development and Mines, 1987, and Statistics Canada, 1986.*

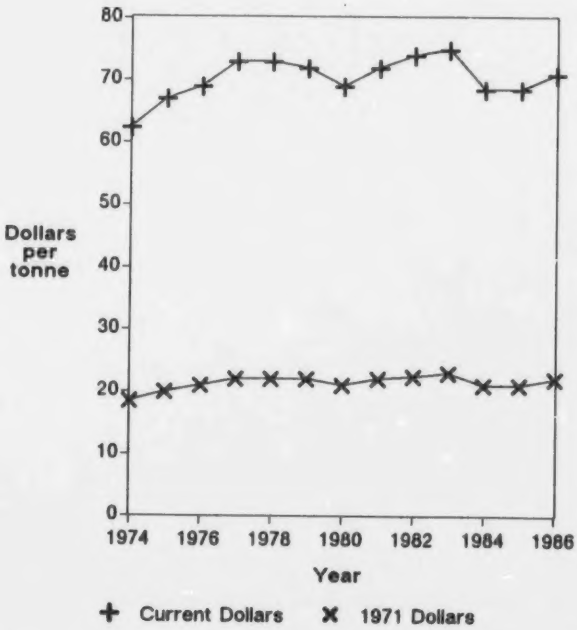


**Figure 4.11. ONTARIO CEMENT, COST PER TONNE IN 1971 AND CURRENT DOLLARS.** *Source: "Ontario Mineral Score", Ontario Ministry of Northern Development and Mines, 1986.*

**Table 4.4. ONTARIO CONSTRUCTION ACTIVITY, 1980-1986.**

| Type of construction | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 |
|---|---|---|---|---|---|---|---|
| | ($million) | | | | | | |
| Residential | 4,229.8 | 4,998.8 | 4,475.3 | 5,875.4 | 6,313.5 | 7,463.2 | 8,775.9 |
| Industrial | 1,146.9 | 1,380.3 | 1,031.1 | 921.9 | 1,175.3 | 1,602.4 | 1,790.3 |
| Commercial | 1,682.6 | 1,865.3 | 2,166.6 | 2,102.6 | 2,612.6 | 3,151.4 | 3,546.5 |
| Institutional | 447.8 | 524.0 | 655.7 | 716.3 | 789.8 | 840.5 | 902.5 |
| Other building | 458.1 | 583.5 | 568.4 | 498.1 | 518.8 | 515.5 | 568.7 |
| Engineering | 4,042.3 | 4,836.5 | 5,510.6 | 4,856.5 | 5,359.6 | 5,378.9 | 5,394.4 |
| Total | 12,007.5 | 14,188.4 | 14,407.7 | 14,970.8 | 16,769.6 | 18,951.9 | 20,978.3 |

*Source: Statistics Canada, 1986*

between 3% and 4% of the total cost of construction materials.

Data on cement demand by type of construction activity is very difficult to obtain, though the results of some research conducted by the Canadian Portland Cement Association are shown in Table 4.5. Assuming these data to be correct, the estimated distribution of cement shipments in Canada and Ontario in 1985 and 1986 is as shown in Figure 4.13.

Data on US demand patterns by end-use for cement is provided in Table 4.6. It is seen that ready-mix and concrete products manufacturers are by far the largest users of cement. Similar end-use patterns are believed to prevail for Canada and for Ontario cement consumption.

A forecast of cement production is provided in Figure 4.14, based on a simple linear regression model and should be regarded as indicative only. The forecast predicts Ontario cement production will decrease to approximately 3,250,000 tonnes by 1995, but could range

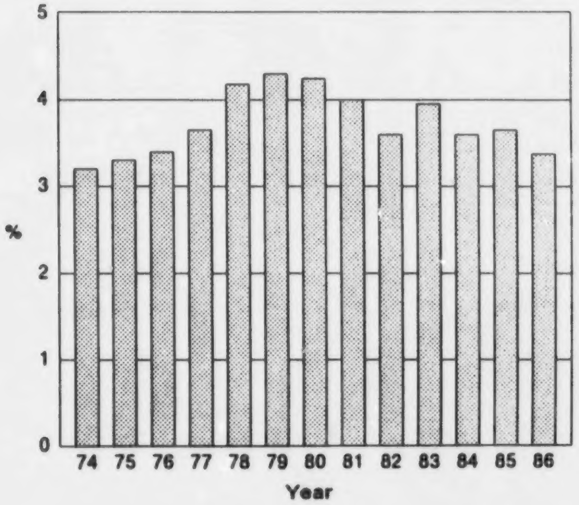


**Figure 4.12. ONTARIO CEMENT, SALES AS % OF CONSTRUCTION MATERIAL COSTS.** *Source: "Ontario Mineral Score", Ontario Ministry of Northern Development and Mines, 1986 and Statistics Canada, 1986.*

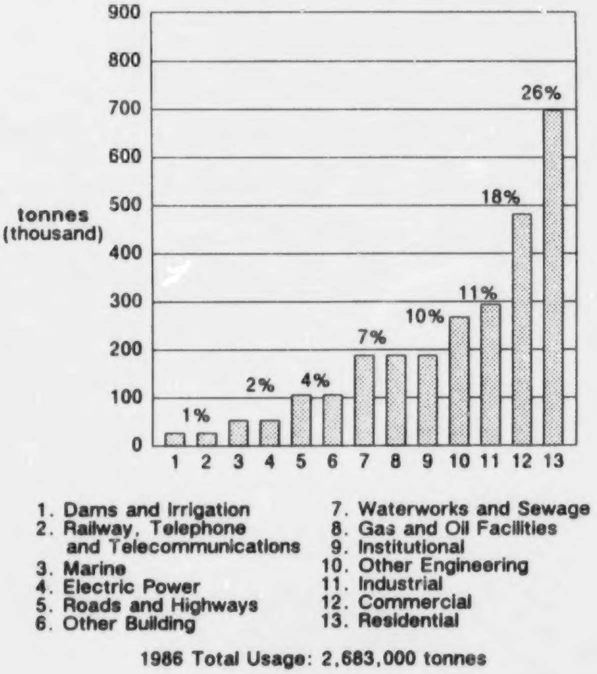


**Figure 4.13. USE OF CEMENT IN ONTARIO, BY TYPE OF STRUCTURE.** *Source: derived from Canadian Portland Cement Association and Statistics Canada data.*

**Table 4.5 APPARENT USE OF CEMENT IN CANADA.**

| Type of structure | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | tonnes (000) | | | | | | | | | | |
| *Total Construction* | 9,016 | 8,566 | 8,441 | 8,282 | 8,368 | 8,428 | 7,962 | 7,758 | 5,994 | 5,847 | 6,000 |
| *Total Building Construction* | 6,779 | 6,149 | 6,010 | 6,363 | 8,928 | 6,000 | 5,480 | 5,280 | 3,743 | 3,850 | 3,987 |
| **Residential - Total** | 3,412 | 2,764 | 3,050 | 4,132 | 3,237 | 2,890 | 2,149 | 2,022 | 1,217 | 1,698 | 1,621 |
| Single detached | 2,233 | 1,800 | 1,948 | 1,763 | 2,073 | 1,776 | 1,342 | 1,340 | 644 | 1,156 | 1,093 |
| Semi-detached, incl. duplexes | 257 | 207 | 224 | 203 | 238 | 222 | 157 | 136 | 77 | 67 | 57 |
| Apartments, incl. row housing | 800 | 645 | 698 | 631 | 743 | 710 | 494 | 404 | 387 | 341 | 333 |
| Other residential bldg. | 76 | 70 | 135 | 100 | 131 | 129 | 108 | 99 | 71 | 92 | 92 |
| Maintenance & repair | 45 | 43 | 46 | 37 | 51 | 53 | 48 | 45 | 38 | 43 | 45 |
| **Industrial - Total** | 1,120 | 935 | 766 | 684 | 767 | 936 | 1,159 | 1,129 | 742 | 512 | 612 |
| Factories, plants | 1,048 | 862 | 697 | 633 | 723 | 873 | 1,088 | 1,053 | 683 | 450 | 557 |
| Mining buildings | 32 | 24 | 32 | 22 | 11 | 18 | 33 | 45 | 34 | 33 | 21 |
| Railway stations, roadway bldgs. | 17 | 23 | 14 | 13 | 12 | 16 | 7 | 8 | 6 | 5 | 6 |
| Other railway bldgs. | 9 | 13 | 8 | 5 | 7 | 13 | 14 | 7 | 8 | 13 | 15 |
| Maintenance & repair | 15 | 14 | 10 | 12 | 15 | 15 | 17 | 16 | 11 | 12 | 14 |
| **Commercial - Total** | 1,350 | 1,522 | 1,328 | 932 | 1,171 | 1,435 | 1,408 | 1,370 | 1,098 | 987 | 1,081 |
| Warehouse & other storage | 183 | 192 | 191 | 147 | 131 | 229 | 208 | 217 | 145 | 148 | 127 |
| Grain elevators | 9 | 11 | 14 | 18 | 21 | 21 | 19 | 18 | 20 | 44 | 39 |
| Hotels, restaurants, clubs, etc. | 181 | 128 | 84 | 45 | 94 | 136 | 134 | 137 | 109 | 101 | 110 |
| Office bldgs. | 412 | 448 | 467 | 347 | 436 | 447 | 502 | 509 | 451 | 403 | 418 |
| Stores, retail & wholesale | 248 | 232 | 240 | 191 | 286 | 383 | 343 | 305 | 194 | 156 | 165 |
| Garages & service stations | 94 | 84 | 75 | 57 | 72 | 43 | 51 | 54 | 43 | 44 | 59 |
| Theatres, arenas & recr. bldgs. | 188 | 397 | 244 | 98 | 117 | 141 | 138 | 115 | 125 | 108 | 148 |
| Laundries & dry cleaning est. | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 |
| Maintenance & repair | 12 | 10 | 12 | 9 | 13 | 14 | 13 | 12 | 11 | 12 | 13 |
| **Institutional - Total** | 624 | 623 | 588 | 423 | 517 | 505 | 508 | 490 | 443 | 441 | 459 |
| Schools & educational bldgs. | 391 | 378 | 327 | 244 | 285 | 262 | 232 | 218 | 201 | 190 | 176 |
| Churches & religious bldgs. | 8 | 11 | 14 | 11 | 15 | 17 | 23 | 19 | 16 | 18 | 17 |
| Hospitals, clinics, etc. | 154 | 138 | 141 | 92 | 133 | 135 | 171 | 161 | 159 | 160 | 159 |
| Other institutional bldgs. | 68 | 93 | 101 | 72 | 79 | 86 | 78 | 87 | 82 | 89 | 102 |
| Maintenance & repair | 5 | 4 | 4 | 4 | 5 | 5 | 4 | 5 | 5 | 5 | 5 |
| **Other building construction - Total** | 273 | 304 | 278 | 192 | 236 | 234 | 257 | 269 | 223 | 191 | 214 |
| Farm bldgs. (excl. dwellings) | 100 | 95 | 98 | 83 | 113 | 119 | 131 | 129 | 107 | 90 | 104 |
| Radio, T.V. & phone relay stations | 35 | 42 | 42 | 25 | 29 | 34 | 35 | 41 | 31 | 17 | 21 |
| Aircraft hangars | 4 | 20 | 11 | 9 | 10 | 11 | 19 | 18 | 16 | 8 | 7 |
| Passenger terminals | 79 | 91 | 73 | 44 | 39 | 23 | 32 | 32 | 28 | 25 | 27 |
| Armouries, barracks, etc. | 3 | 7 | 5 | 3 | 6 | 6 | 3 | 3 | 2 | 6 | 9 |
| Bunkhouses, dormitories, etc. | 14 | 8 | 14 | 7 | 6 | 7 | 13 | 15 | 6 | 3 | 5 |
| Laboratories | 22 | 21 | 15 | 8 | 9 | 12 | 11 | 18 | 23 | 24 | 29 |
| Other building construction | 10 | 13 | 11 | 7 | 17 | 14 | 7 | 6 | 6 | 6 | 7 |
| Maintenance & repair | 6 | 6 | 6 | 5 | 7 | 7 | 6 | 6 | 5 | 6 | 5 |

Table 4.5. CONTINUED.

| Type of structure | tonnes (000)<br>1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Total Engineering Construction* | 2,237 | 2,417 | 2,431 | 1,920 | 2,430 | 2,428 | 2,482 | 2,478 | 2,251 | 1,997 | 2,013 |
| **Marine construction - Total** | 182 | 144 | 115 | 111 | 127 | 123 | 122 | 133 | 151 | 133 | 140 |
| Docks, piers, breakwaters, etc. | 121 | 81 | 49 | 60 | 66 | 72 | 67 | 86 | 85 | 70 | 81 |
| Retaining walls, embankments | 12 | 10 | 11 | 9 | 11 | 7 | 6 | 8 | 3 | 6 | 6 |
| Canals & waterways | 10 | 4 | 7 | 8 | 8 | 8 | 8 | 8 | 7 | 6 | 8 |
| Dredging & pile driving | 10 | 7 | 5 | 7 | 10 | 5 | 14 | 9 | 15 | 13 | 10 |
| Dyke construction | 7 | 27 | 31 | 15 | 19 | 14 | 19 | 10 | 10 | 14 | 8 |
| Logging booms | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Other marine construction | 9 | 13 | 10 | 11 | 10 | 14 | 6 | 8 | 30 | 22 | 24 |
| Maintenance & repair | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 3 | 2 | 2 | 2 |
| **Roads, highways & runways - Total** | 362 | 353 | 352 | 279 | 384 | 356 | 337 | 296 | 255 | 252 | 268 |
| Highway, road & street constr. | 233 | 225 | 210 | 169 | 233 | 228 | 207 | 192 | 158 | 157 | 157 |
| Parking lots | 13 | 11 | 21 | 12 | 17 | 13 | 16 | 11 | 13 | 11 | 15 |
| Sidewalks & paths | 73 | 88 | 94 | 82 | 116 | 98 | 94 | 75 | 65 | 60 | 66 |
| Runways, landing fields, tarmac | 38 | 24 | 23 | 12 | 12 | 10 | 15 | 13 | 15 | 19 | 25 |
| Maintenance & repair | 5 | 5 | 5 | 4 | 5 | 6 | 6 | 5 | 5 | 5 | 5 |
| **Waterworks & sewage systems - Total** | 609 | 620 | 696 | 555 | 704 | 661 | 597 | 510 | 447 | 451 | 441 |
| Drainage ditches, storm sewers | 59 | 61 | 70 | 57 | 85 | 83 | 80 | 74 | 52 | 51 | 48 |
| Water mains, hydrants & services | 103 | 94 | 109 | 90 | 129 | 110 | 103 | 94 | 72 | 69 | 75 |
| Sewage systems disposal plants | 396 | 398 | 426 | 333 | 340 | 319 | 282 | 230 | 207 | 205 | 208 |
| Water pumping stations, plants | 36 | 53 | 77 | 62 | 132 | 133 | 117 | 99 | 102 | 113 | 96 |
| Water storage tanks | 6 | 5 | 5 | 5 | 8 | 7 | 7 | 6 | 6 | 6 | 7 |
| Maintenance & repair | 9 | 8 | 8 | 7 | 10 | 9 | 7 | 7 | 7 | 7 | 8 |
| **Dams & irrigation - Total** | 68 | 75 | 63 | 56 | 66 | 71 | 73 | 92 | 77 | 70 | 72 |
| Dams & reservoirs | 33 | 28 | 17 | 13 | 23 | 26 | 25 | 43 | 28 | 14 | 18 |
| Irrigation & land recl. projects | 33 | 46 | 44 | 42 | 41 | 43 | 48 | 48 | 48 | 55 | 53 |
| Maintenance & repair | 2 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Electric power construction - Total** | 111 | 151 | 149 | 127 | 149 | 164 | 140 | 129 | 103 | 93 | 69 |
| Electric power generating plants | 86 | 121 | 122 | 105 | 136 | 131 | 110 | 102 | 79 | 71 | 45 |
| Electric transformer stations | 2 | 2 | 2 | 1 | 2 | 1 | 3 | 2 | 2 | 2 | 2 |
| Power trans. & distr. lines | 17 | 21 | 9 | 15 | 23 | 25 | 21 | 19 | 18 | 14 | 17 |
| Street lighting | 2 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 1 | 1 | 1 |
| Maintenance & repair | 4 | 4 | 5 | 4 | 5 | 5 | 5 | 4 | 3 | 3 | 4 |
| **Railway, telephone, telegraph - Total** | 48 | 45 | 48 | 35 | 44 | 47 | 48 | 46 | 48 | 49 | 47 |
| Railway tracks & roadbeds | 26 | 26 | 26 | 19 | 22 | 26 | 29 | 29 | 35 | 37 | 35 |
| Signals & interlockers | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 |
| Telephone & telegraph lines | 18 | 15 | 17 | 13 | 17 | 17 | 15 | 14 | 11 | 8 | 9 |
| Maintenance & repair | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |

Table 4.5. CONTINUED.

| Type of structure | tonnes (000)<br>1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Gas & oil facilities - Total** | 226 | 224 | 194 | 176 | 235 | 297 | 402 | 593 | 566 | 358 | 349 |
| Gas mains & services | 24 | 20 | 18 | 14 | 19 | 14 | 16 | 23 | 22 | 24 | 27 |
| Pumping stations, oil | 6 | 6 | 2 | 2 | 0 | 0 | 0 | 1 | 3 | 0 | 1 |
| Pumping stations, gas | 7 | 2 | 1 | 2 | 0 | 0 | 0 | 3 | 2 | 1 | 2 |
| Oil storage tanks | 4 | 9 | 5 | 3 | 2 | 2 | 1 | 4 | 4 | 4 | 3 |
| Gas storage tanks | 2 | 2 | 2 | 1 | 3 | 1 | 0 | 1 | 1 | 1 | 1 |
| Oil pipe lines | 20 | 49 | 7 | 1 | 2 | 7 | 12 | 23 | 10 | 16 | 34 |
| Gas pipe lines | 26 | 17 | 7 | 14 | 3 | 14 | 70 | 239 | 251 | 59 | 50 |
| Oil & gas wells | 84 | 71 | 95 | 91 | 152 | 208 | 252 | 217 | 181 | 192 | 204 |
| Oil refinery - processing units | 27 | 23 | 26 | 24 | 24 | 11 | 14 | 46 | 55 | 42 | 25 |
| Natural gas processing plants | 19 | 16 | 20 | 14 | 19 | 27 | 22 | 25 | 29 | 11 | 14 |
| Maintenance & repair | 8 | 8 | 10 | 8 | 11 | 12 | 14 | 11 | 8 | 8 | 7 |
| **Other engineering construction - Total** | 631 | 805 | 812 | 581 | 703 | 709 | 762 | 679 | 603 | 591 | 607 |
| Bridges, trestles, overpasses | 209 | 302 | 255 | 157 | 279 | 231 | 222 | 181 | 155 | 138 | 191 |
| Tunnels & subways | 14 | 36 | 57 | 33 | 31 | 24 | 22 | 19 | 23 | 46 | 26 |
| Incinerators | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 2 |
| Park systems, landscaping | 29 | 17 | 21 | 26 | 36 | 34 | 35 | 31 | 32 | 29 | 31 |
| Swimming pools, tennis courts | 9 | 14 | 8 | 7 | 13 | 13 | 11 | 12 | 8 | 10 | 14 |
| Mine shafts | 256 | 251 | 296 | 235 | 267 | 311 | 358 | 355 | 320 | 303 | 284 |
| Fences, signs, guardrails | 15 | 15 | 14 | 13 | 19 | 20 | 22 | 20 | 17 | 16 | 16 |
| Other engineering construction | 91 | 162 | 151 | 102 | 100 | 68 | 82 | 56 | 44 | 43 | 39 |
| Maintenance & repair | 6 | 5 | 6 | 6 | 7 | 7 | 7 | 4 | 4 | 4 | 5 |

*Source: Canadian Portland Cement Association, used by permission.*

Table 4.6. UNITED STATES. PORTLAND CEMENT SHIPMENTS IN 1985, BY DISTRICT OF ORIGIN AND TYPE OF CUSTOMER.[1]

| District of origin | Building material dealers tons (1000's) | % | Concrete product manufacturers tons (1000's) | % | Ready-mixed concrete tons (1000's) | % | Highway contractors tons (1000's) | % | Other contractors tons (1000's) | % | Federal, State, and other government agencies tons (1000's) | % | Miscellaneous including own use tons (1000's) | % | Total[2] tons (1000's) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| New York and Maine | 226 | 6.2 | 559 | 15.4 | 2,517 | 69.2 | 198 | 5.4 | 120 | 3.3 | 1 | - | 20 | 0.5 | 3,369 |
| Pennsylvania, eastern | 377 | 8.8 | 1,072 | 25.1 | 2,692 | 63.0 | 38 | 0.9 | 30 | 0.7 | ([3]) | - | 63 | 1.5 | 4,272 |
| Pennsylvania, western | 227 | 18.0 | 21.4 | 16.9 | 703 | 55.6 | 72 | 5.7 | 48 | 3.8 | - | - | - | - | 1,268 |
| Maryland, Virginia, West Virginia | 177 | 5.2 | 599 | 17.6 | 2,395 | 70.5 | 72 | 2.1 | 78 | 2.3 | 40 | 1.2 | 30 | 1.1 | 3,399 |
| Ohio | 134 | 7.5 | 270 | 15.2 | 1,244 | 70.3 | 115 | 6.5 | 6 | 0.3 | - | - | 1 | 0.1 | 1,769 |
| Michigan and Wisconsin | 148 | 3.2 | 619 | 13.2 | 3,581 | 76.3 | 285 | 5.0 | 88 | 1.9 | 7 | 0.1 | 16 | 0.8 | 4,695 |
| Indiana and Kentucky | 129 | 5.4 | 382 | 13.9 | 1,724 | 72.2 | 128 | 5.2 | 37 | 1.5 | - | - | 44 | 1.8 | 2,389 |
| Illinois | 66 | 3.1 | 202 | 9.6 | 1,647 | 78.4 | 102 | 4.9 | 51 | 2.4 | - | - | 33 | 1.6 | 2,101 |
| Georgia and Tennessee | 166 | 7.7 | 561 | 25.9 | 1,274 | 59.0 | 31 | 1.4 | 119 | 5.5 | 2 | 0.1 | 8 | 0.4 | 2,162 |
| South Carolina | 57 | 2.6 | 386 | 17.5 | 1,662 | 75.3 | 23 | 1.0 | 52 | 2.4 | 3 | 0.1 | 25 | 1.1 | 2,307 |
| Florida | 425 | 13.0 | 395 | 12.0 | 2,232 | 68.0 | 81 | 2.5 | 101 | 3.1 | 14 | 0.4 | 32 | 1.0 | 3,282 |
| Alabama | 328 | 8.8 | 545 | 14.7 | 2,481 | 66.7 | 187 | 5.0 | 91 | 2.4 | 19 | 0.5 | 70 | 1.9 | 3,721 |
| Arkansas, Louisiana, Mississippi | 134 | 6.3 | 200 | 9.4 | 1,223 | 57.3 | 115 | 5.4 | 301 | 14.1 | 14 | 0.7 | 145 | 6.8 | 2,188 |
| South Dakota | 9 | 1.3 | 28 | 4.3 | 347 | 52.9 | 136 | 20.8 | 12 | 1.8 | - | - | 124 | 18.9 | 656 |
| Iowa | 53 | 3.3 | 295 | 18.2 | 963 | 59.5 | 277 | 17.1 | 8 | 0.5 | 6 | 0.4 | 16 | 1.0 | 1,618 |
| Missouri | 104 | 2.8 | 377 | 10.3 | 2,813 | 76.6 | 22 | 6.0 | 76 | 2.1 | - | - | 79 | 2.2 | 3,669 |
| Kansas and Nebraska | 63 | 2.5 | 136 | 5.3 | 1,756 | 68.9 | 283 | 11.1 | 271 | 10.6 | 1 | - | 42 | 1.6 | 2,550 |
| Oklahoma | 48 | 3.0 | 70 | 4.4 | 1,103 | 69.4 | 148 | 9.3 | 192 | 12.1 | 2 | 0.1 | 25 | 1.6 | 1,589 |
| Texas, northern | 314 | 5.9 | 410 | 7.8 | 2,710 | 51.3 | 394 | 7.4 | 1,239 | 28.4 | 98 | 1.9 | 122 | 2.3 | 5,287 |
| Texas, southern | 277 | 5.6 | 468 | 9.4 | 3,245 | 65.5 | 286 | 5.4 | 619 | 12.5 | 22 | 0.4 | 58 | 1.2 | 4,955 |
| Idaho, Montana, Utah | 52 | 3.0 | 130 | 7.5 | 1,085 | 62.2 | 179 | 10.3 | 268 | 15.4 | - | - | 28 | 1.6 | 1,743 |
| Colorado and Wyoming | 46 | 2.9 | 173 | 10.9 | 1,156 | 73.1 | 144 | 9.1 | 58 | 3.7 | - | - | 5 | 0.3 | 1,582 |
| Alaska, Oregon, Washington | 35 | 2.1 | 113 | 6.6 | 1,320 | 77.7 | 158 | 9.3 | 32 | 1.9 | - | - | 41 | 2.4 | 1,700 |
| Arizona, Nevada, New Mexico | 79 | 3.6 | 364 | 16.1 | 1,456 | 66.4 | 45 | 2.1 | 239 | 10.9 | 2 | 0.1 | 17 | 0.8 | 2,192 |
| California, northern | 163 | 6.3 | 298 | 11.5 | 2,007 | 77.4 | 27 | 1.0 | 75 | 2.9 | 7 | 0.2 | 18 | 0.7 | 2,596 |
| California, southern | 439 | 6.4 | 883 | 12.9 | 5,060 | 73.6 | 12 | 0.2 | 387 | 5.6 | 17 | 0.2 | 68 | 1.0 | 6,868 |
| Hawaii | 14 | 6.5 | 30 | 14.0 | 152 | 70.7 | 2 | 0.3 | 11 | 5.1 | 2 | 0.9 | 4 | 1.9 | 215 |
| Foreign imports[4] | 73 | 2.0 | 52 | 1.5 | 5,402 | 96.3 | 3 | 0.1 | - | - | - | - | 3 | 0.1 | 5,532 |
| Total[2] or average | 4,363 | 5.5 | 9,771 | 12.2 | 55,950 | 70.1 | 3,687 | 4.6 | 4,609 | 5.8 | 257 | 0.3 | 1,145 | 1.5 | 79,781 |
| Puerto Rico | 467 | 48.5 | 44 | 4.6 | 430 | 44.7 | - | - | 18 | 1.9 | 2 | 0.2 | 1 | 0.1 | 962 |

[1] *Includes Puerto Rico.*

[2] *Data may not add to totals shown because of independent rounding.*

[3] *Less 1/2 unit.*

[4] *Cement imported and distributed by domestic producers only. Source of imports withheld to avoid disclosing company proprietary data.*

*Source: U.S. Bureau of Mines, Minerals Yearbook, Cement, 1985.*

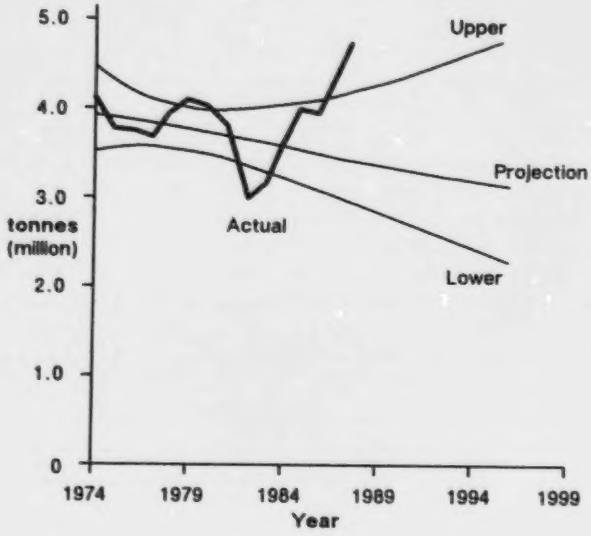


**Figure 4.14.** ONTARIO CEMENT PRODUCTION FORECAST, DATA, PROJECTION AND 95% LIMITS.

from a high level of approximately 4,400,000 tonnes to a low level of approximately 2,400,000 tonnes by that date. In all cases though, cement production capacity will significantly exceed the forecast demand level. Estimates of US cement demand in the year 2000 range from a low of 85 million tons to a high of 115 million tons, with 100 million tons being the most probable demand level. The data are provided in Table 4.7. These data should be compared to total US demand for cement of 91.8 million tons in 1986 and US clinker production capacity of approximately 90.0 million tons. It is obvious that imports will continue to fulfill a significant proportion of US cement demand for the foreseeable future.

Factors which could have an impact on cement demand, exclusive of variations in construction activity, include the following:

- A change in commercial construction to the use of reinforced and pre–cast concrete in place of structural steel. Much of the construction activity in southern Ontario is now of reinforced and pre–cast concrete. There has been a decided shift away from structural steel construction for many large office buildings. An example is the new Scotia Plaza tower in Toronto, a 68 storey reinforced concrete building. This building would have been constructed of structural steel if built 20 years ago.

**Table 4.7. PROJECTIONS AND FORECASTS FOR US CEMENT DEMAND BY END USE–2000.**

| | | 2000 | | | |
|---|---|---|---|---|---|
| | | | Contingency forecast for US | | |
| | | Statistical | Forecast range | | |
| End use | 1983 | projections[1] | Low | High | Probable |
| | | (Million short tons) | | | |
| Ready–mixed concrete | 47 | 72 | 60 | 80 | 70 |
| Concrete product manufacturers | 8 | 14* | 11 | 15 | 14 |
| Highway contractors | 4 | 0* | 1 | 1 | 1 |
| Building material dealers | 5 | 4* | 4 | 5 | 4 |
| Other | 10 | 14* | 9 | 14 | 11 |
| Total | 74 | – | 85 | 115 | 100 |

[1] *Statistical projections, provided by the Branch of Economic Analysis, are derived from regression analyses based on historical time series data and forecasts of economic indicators such as GNP, and FRB index. A statistical projection of zero indicates that demand will vanish at or before the year 2000, based on the historical relationship. Projection equations with a coefficient of determination (R–squared) less than 0:70 are indicated by an asterisk (*).*
*Source: US Bureau of Mines, Minerals Yearbook, Cement.*

- Increased use of large reinforced pre–cast, pre–stressed structures for engineering construction for bridges, highways, buildings, etc.
- Increased use of concrete products such as pipe and blocks and development of new cement products such as cement bricks. Cement bricks now have 25% of the Ontario brick market, and are increasing rapidly in market share.
- Increased use of cement in highway construction. At present, cement is not used to any extent as the primary road surface in Canada. This is in contrast to the US, where cement is much more frequently employed in highway construction and repair.

## CEMENT TRADE

Cement is a low cost bulk commodity and traditionally has not traded more than about 500 km from a producer's plant if land transportation is required. Ontario is in a unique position with regard to cement trade in that the Great Lakes offer the possibility of low cost shipment to almost all of the major markets in Ontario, and to a large part of the US market.

Data on Canadian imports and exports of cement and concrete basic products are provided in Table 4.8. As can be seen, Canada is a large net exporter of clinker, finished cement, and concrete products. The United States is by far the largest customer for Canadian cement, accounting for approximately 98% to 99% of exports in any given year. Contributing factors to the export success of Canadian and Ontario cement producers are the following:

- Lower production costs than U.S plants, especially for energy and labour. US plants tend to be older and less efficient than Ontario cement plants. This is especially true for the plants bordering the US side of the Great Lakes.
- A high degree of market integration. Much of Ontario's cement exports are destined for captive consumption in the US. Major facilities operated in the US by Ontario based cement producers are listed in Table 4.9.
- Low cost water transport of clinker and cement. Canadian ships are generally cheaper to operate than US ships. Specialized ships are employed on either an owned or long– term charter basis. This provides Ontario producers a significant degree of control over transportation costs.

Canadian and Ontario imports of clinker, cement, and concrete products primarily relate to cements not produced in Canada. For example, there is no domestic manufacture of aluminous cement and limited domestic manufacture of refractory cements and mortars. Imports of clinker are restricted to coastal regions such as the Maritimes where low ocean freight rates allow offshore material to be competitive with domestic cement. The principal sources of imported clinker are Spain, Belgium, and Venezuela, though the quantities imported from these countries are limited at present.

The United States is now the world's largest importer of cement and clinker. Imports of cement into the US have increased rapidly in recent years, accounting for 4% of US cement demand in 1982 and 19% of demand in

**Table 4.8. CANADIAN CEMENT AND CONCRETE PRODUCTS TRADE.**

| | | | ($'000) | | | |
|---|---|---|---|---|---|---|
| **Imports** | **1980** | **1981** | **1982** | **1983** | **1984** | **1985** |
| Clinker | 30 | 1,963 | 92 | 2 | 4 | 2,975 |
| Cement | 8,959 | 32,508 | 14,451 | 16,132 | 16,801 | 16,138 |
| White cement | 603 | 475 | 694 | 458 | 547 | 396 |
| Aluminum cement | 2,795 | 2,844 | 926 | 1,173 | 2,005 | 1,999 |
| Other cements | 6,289 | 19,286 | 4,856 | 2,835 | 2,438 | 5,431 |
| Cement & concrete basic products | 2,701 | 3,045 | 2,801 | 4,001 | 4,000 | 4,181 |
| Total | 21,377 | 57,561 | 23,820 | 24,601 | 25,795 | 31,120 |
| **Exports** | | | | | | |
| Cement | 65,066 | 68,687 | 79,523 | 74,707 | 105,912 | 128,356 |
| Prestressed concrete structural products | 12,393 | 13,605 | 19,051 | 10,976 | 13,131 | 26,100 |
| Cement & other concrete basic products | 40,005 | 35,588 | 31,973 | 46,378 | 59,686 | 55,976 |
| Total | 117,464 | 117,880 | 130,547 | 132,061 | 178,729 | 210,432 |

*Source: Statistics Canada, 1986.*

1986. The rapid rise in imports is attributable to the following:

- A strategic decision by some US producers to utilize low cost imported clinker in place of high cost clinker produced in their own kilns.
- A rapid expansion in the degree of foreign ownership of the US cement industry, and a shift to the use of clinker from parent company kilns in Europe. Foreign ownership now accounts for approximately 41% of US cement production capacity.
- A general lack of investment in plant modernizations and expansions, resulting in higher cost domestic facilities.
- A significant expansion in cement production facilities in low cost countries such as Spain and Mexico. Producers in these countries are seeking markets for their product, and the United States represents the most remunerative market.

**Table 4.9. US CEMENT FACILITIES OWNED BY ONTARIO-BASED CEMENT COMPANIES.**

**Lake Ontario Cement**

Rochester Portland Cement
    cement terminals at Rochester and Rome, N.Y.

Aetna Cement Corp.
    clinker grinding and cement terminal at Essexville, Michigan

Universal Concrete Products
    concrete pipe and products manufacturing operations in Pennsylvania, Ohio, Kentucky, Tennessee, N. Carolina, S. Carolina

**St. Marys Cement**

St. Marys Wyandotte Cement Inc.
    clinker grinding and cement terminal at Wyandotte, Michigan

St. Marys Wisconsin Cement Inc.
    clinker grinding plant at Milwaukee, Wisconsin and distribution terminals at Green Bay, Wisconsin and Waukegan, Illinois

**St. Lawrence Cement**

Independent Cement Corp.
    cement plants at Catskill, N.Y. and Hagerstown, Md.

    Distribution terminals in Connecticut, Maine, Maryland, Massachusetts, Minnesota, New York, Pennsylvania, Rhode Island

**Lafarge Canada**

Owns General Portland Cement, second largest cement producer in US, with operations throughout US.

Huron Cement Corp.

*Source: Company reports.*

Canada has supplied approximately 40% of US cement imports in the recent past. Imports from other countries such as Spain, Mexico, and Japan have been increasing rapidly, and the Canadian share of the market has declined accordingly. The Canadian share of the US import market stood at 52% in 1983 and 23% in 1985. However, within the area accessible by Great Lakes vessels, US imports from Canada have increased. Table 4.10 illustrates recent patterns in US imports of cement and clinker.

The outlook for US cement and clinker imports is for a continuation of recent patterns. Imports are expected to increase in concert with US cement demand and the closure of high cost domestic production facilities. The recent passage of the revised U.S Surface Transportation Assistance Act (Highway Act) should do much to stimulate demand for cement. Major US interstate highways and bridges are in need of significant repair in the next few years. The revised act eliminates the Buy America provisions which precluded the use of foreign cement in highway construction. Thus there are now no significant tariff and non– tariff barriers to the use of imported cement in the US.

## CEMENT PRICES

Recent prices for cement are illustrated in Table 4.11.

It is seen that the average price for cement in Ontario has been consistently below the average price for Canada as a whole. The lower price for Ontario is believed to reflect a combination of the more competitive nature of the Ontario market and a greater reliance on standard Type I and II cements rather than the premium priced specialty cements.

Price data for the various types of cement are not readily available for Canada or for Ontario. Price data for the US is given in Table 4.12.

US prices for cement have been consistently above those in Ontario, the price differential sufficient to have attracted Ontario cement producers to the US market. A detailed analysis of cement prices in the US market area bordering the Great Lakes is provided in Table 4.13, the data indicating the marked geographic differences in cement prices. The data also indicate that Ontario cement prices are quite similar to prices in the region accessible by water transport. Despite the similarity in prices Ontario cement producers are attracted to the US market for several reasons. Among these are:

- The US market offers an opportunity to sell additional volume at what is essentially variable cost. Without this additional volume most of the Ontario cement industry would be significantly less profitable.
- The business cycles in Ontario and the US region bordering the Great Lakes have often been different.

### Table 4.10. US IMPORTS FOR CONSUMPTION OF HYDRAULIC CEMENT AND CLINKER, BY COUNTRY.

(Thousand short tons and thousand dollars)

| | 1983 | | | 1984 | | | 1985 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Quantity | Value | | Quantity | Value | | Quantity | Value | |
| Country | | Customs | C.i.f. | | Customs | C.i.f. | | Customs | C.i.f. |
| Canada | 2,201 | 86,198 | 92,851 | 2,945 | 116,815 | 128,920 | 3,393 | 181,117 | 145,005 |
| Colombia | 68 | 8,845 | 4,169 | 227 | 5,138 | 6,927 | 662 | 16,430 | 20,244 |
| France | 158 | 6,435 | 7,507 | 225 | 7,044 | 9,180 | 552 | 13,866 | 18,319 |
| Greece | – | – | – | – | – | – | 511 | 9,760 | 12,202 |
| Japan | (2) | 100 | 118 | 183 | 5,287 | 7,595 | 1,184 | 28,786 | 37,105 |
| Korea, Republic of | 69 | 3,228 | 4,144 | 882 | 10,046 | 12,129 | 484 | 26,194 | 29,738 |
| Mexico | 826 | 30,844 | 33,539 | 2,003 | 64,574 | 74,877 | 2,502 | 75,755 | 87,839 |
| Spain | 787 | 28,883 | 29,303 | 1,760 | 49,584 | 61,218 | 3,383 | 80,448 | 103,353 |
| Venezuela | 60 | 1,705 | 2,138 | 1,022 | 25,281 | 32,224 | 1,569 | 38,282 | 50,320 |
| Other | 154 | 5,751 | 7,756 | 149 | 10,498 | 10,412 | 298 | 16,791 | 20,148 |
| Total | 4,268 | 161,439 | 181,525 | 8,846 | 294,207 | 343,482 | [3]14,487 | 437,429 | 523,773 |

[1] *Cost, insurance and freight.*

[2] *Less than 1/2 unit.*

[3] *Data do not add to total shown because of independent rounding.*

*Source: Bureau of the Census, US Department of Commerce.*

### US IMPORTS FOR CONSUMPTION OF CLINKER, BY COUNTRY.

(Thousand short tons and thousand dollars)

| | 1983 | | | 1984 | | | 1985 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Quantity | Value | | Quantity | Value | | Quantity | Value | |
| Country | | Customs | C.i.f.[1] | | Customs | C.i.f. | | Customs | C.i.f. |
| Canada | 446 | 14,786 | 16,534 | 485 | 16,947 | 19,406 | 746 | 22,156 | 25,763 |
| France | 152 | 6,389 | 7,489 | 225 | 7,491 | 9,180 | 414 | 9,434 | 11,789 |
| Greece | – | – | – | – | – | – | 407 | 7,900 | 9,390 |
| Japan | – | – | – | 69 | 2,927 | 2,698 | 291 | 6,897 | 7,840 |
| Mexico | 192 | 6,899 | 7,373 | 477 | 11,608 | 13,077 | 581 | 14,671 | 16,387 |
| Spain | 214 | 5,559 | 6,437 | 528 | 11,885 | 14,860 | 1,656 | 31,877 | 39,917 |
| Venezuela | – | – | – | 294 | 5,623 | 7,484 | 290 | 5,570 | 7,022 |
| Other | – | – | – | *141 | *3,319 | *3,985 | 248 | 5,062 | 6,305 |
| Total[2] | 1,006 | 33,688 | 37,784 | 2,215 | 59,801 | 70,635 | 4,683 | 103,067 | 124,418 |

**Revised*

[1] *Cost, insurance and freight.*

[2] *Data may not add to totals shown because of independent rounding.*

*Source: Bureau of the Census, US Department of Commerce.*
*US Bureau of Mines, Minerals Yearbook, Cement, 1985.*

**Table 4.11. CEMENT PRICES.**

| | ($/tonne) | | | | |
|---|---|---|---|---|---|
| | 1981 | 1982 | 1983 | 1984 | 1985 |
| Canada | $77.00 | $77.63 | $79.83 | n/a | n/a |
| Ontario | $54.15 | $61.52 | $66.32 | $62.89 | $65.55 |
| US ($US/ton) | $52.46 | $51.43 | $50.45 | $52.24 | $51.87 |
| US ($Cdn/tonne) | $69.35 | $69.97 | $68.55 | $74.58 | $78.10 |

**Table 4.12. US CEMENT PRICES BY CEMENT TYPE.**

| | ($US/tonne) | |
|---|---|---|
| Cement Type | 1984 | 1985 |
| Types I and II | $55.82 | $55.35 |
| Type III | 60.02 | 60.10 |
| Type V | 53.51 | 66.93 |
| Oil Well | 64.88 | 64.59 |
| White | 186.35 | 190.57 |
| Portland slag & Portland pozzolan | 59.99 | 60.77 |
| Expansive | 86.20 | 106.47 |
| Miscellaneous | 69.11 | 73.36 |

*Source:* *US Bureau of Mines Minerals Yearbook, Cement, 1985. It is believed similar price differentials prevail in the Ontario and Canadian cement markets.*

**Table 4.13. AVERAGE CEMENT PRICES.**

| | ($US/tonne) | |
|---|---|---|
| Type of cement and region | 1984 | 1985 |
| **Portland Cement** | | |
| New York and Maine | 55.26 | 53.10 |
| Pennsylvania | 54.13 | 57.26 |
| Ohio | 50.47 | 52.92 |
| Michigan and Wisconsin | 49.80 | 48.63 |
| Illinois | 45.61 | 45.24 |
| Average for region | 51.86 | 52.27 |
| **Masonry Cement** | | |
| New York and Maine | 71.90 | 73.61 |
| Pennsylvania | 77.39 | 76.05 |
| Ohio | 88.34 | 104.36 |
| Michigan and Wisconsin | 72.81 | 71.95 |
| Illinois | n/a | n/a |
| Average for region* | 76.94 | 79.00 |

**Excludes Illinois*

*Source: US Bureau of Mines, Minerals Yearbook, Cement, 1985.*

Such differences have allowed Ontario producers to offset declines in one market with advances in the other.

- The US region bordering the Great Lakes is one of declining domestic clinker capacity. Prices are expected to increase at a more rapid rate in the region than in Ontario.

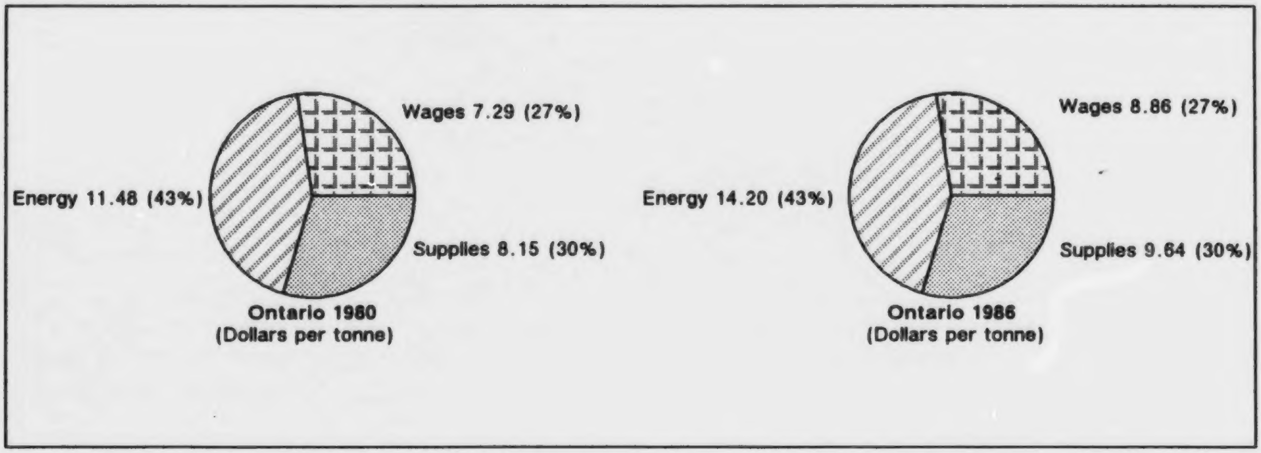
## CEMENT PRODUCTION COSTS

The principal cost factors in the production of cement are fuel (45%), labour (30%), maintenance (10%), raw materials (10%), and overhead (5%). Direct costs for Ontario cement production for the period 1980–1986 are illustrated in Figure 4.15. Over that time period direct costs have increased by 6.3% per annum. During the same period cement prices increased at a compound annual rate of over 4%, while production increased at a rate of 2.7% per annum. These data would tend to indicate that cement prices in Ontario respond more to cost factors than to supply/demand factors. Such a pattern is characteristic of a mature industry with significant excess capacity.

The Ontario cement industry has taken significant efforts to reduce its unit costs of production. For example, Lafarge Canada stated in its 1986 annual report that unit costs were reduced 5% in 1986 over 1985 costs, and that unit costs were reduced by 3% in 1985 and 4% in 1984. The other cement producers are undertaking similar cost reduction programs.

## CEMENT DISTRIBUTION

The integrated nature of Ontario's cement producers has had an impact on cement distribution patterns and methods. Whereas cement used to be shipped primarily in small lots in bags and drums to end users, it is now primarily shipped in bulk by ship, truck and rail car to distribution terminals and ready-mix plants owned by the cement companies. All of the Ontario cement producers operate large fleets of specialized bulk trucks equipped with pneumatic loading and discharge equipment. Rail cars are also specialized for the transport of cement, and



**DIRECT COSTS OF CEMENT PRODUCTION**

| | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 |
|---|---|---|---|---|---|---|---|
| | | | | ($000) | | | |
| Wages | 29,634 | 34,896 | 34,360 | 35,203 | 37,229 | 38,464 | 42,889 |
| Energy | 46,702 | 51,387 | 47,681 | 45,230 | 53,361 | 66,130 | 68,753 |
| Supplies | 33,162 | 33,436 | 29,762 | 31,802 | 35,474 | 45,768 | 46,670 |
| TOTAL | 109,498 | 119,719 | 111,803 | 112,235 | 126,064 | 150,362 | 158,312 |
| | | | | $/TONNE OF CEMENT | | | |
| Wages | 7.286 | 9.214 | 11.426 | 10.998 | 10.391 | 9.511 | 8.856 |
| Energy | 11.483 | 13.569 | 15.857 | 14.130 | 14.893 | 16.353 | 14.196 |
| Supplies | 8.153 | 8.829 | 9.896 | 9.936 | 9.901 | 11.318 | 9.637 |

**Figure 4.15. COST OF CEMENT PRODUCTION, ONTARIO 1980 TO 1986.** *Source: "Ontario Mineral Score", Ontario Ministry of Northern Development and Mines, 1987.*

**Table 4.14. ONTARIO MOVEMENTS OF CEMENT BY WATER.**

| | ('000 tonnes) Destination | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Canadian Ports | | | | | | Foreign Ports | | | | | |
| **Origin** | **1980** | **1981** | **1982** | **1983** | **1984** | **1985** | **1980** | **1981** | **1982** | **1983** | **1984** | **1985** |
| Bath | 174.9 | 308.3 | 204.4 | 262.5 | 238.4 | 163.7 | 52.8 | 63.8 | 20.4 | 31.7 | 32.3 | 18.4 |
| Picton | 256.7 | 218.9 | 202.8 | 252.5 | 304.0 | 285.5 | 556.3 | 545.3 | 366.9 | 449.3 | 526.0 | 507.8 |
| Clarkson | | 5.0 | | | 13.2 | 28.8 | 83.5 | 174.5 | 116.0 | 193.0 | 234.2 | 308.2 |
| Hamilton | | | | | | | | 5.5 | 3.3 | 1.5 | | 18.0 |
| Toronto | | 0.5 | | | | | 7.3 | | | | | |
| Oshawa | | | | | | | 23.5 | | | | | |
| Windsor | | | | | | | 0.7 | 0.4 | 0.4 | | 0.4 | |
| Bowmanville | | | | | | | 59.2 | 60.1 | 13.7 | 165.6 | 107.2 | |
| Kingston | | | | | | | | 5.3 | | | | 21.8 |
| Port Stanley | | | | | | | | | 24.7 | 41.7 | 50.4 | 51.7 |
| St. Catharines | | | | | | | | | 1.6 | | | |
| Thorold | | | | | | | | | 1.6 | | | |
| Trenton | | | | | | | | | | | | 48.7 |

*Source: Statistics Canada, 1986.*

Table 4.15. EXPORTS OF CEMENT AND CONCRETE PRODUCTS FROM ONTARIO, METHOD OF SHIPMENT.

| | | | | ($'000) | | |
|---|---|---|---|---|---|---|
| Mode | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 |
| Water | 40,550 | 38,087 | 33,115 | 37,302 | 41,564 | 40,975 |
| Road | 21,612 | 24,945 | 29,479 | 32,850 | 38,042 | 64,561 |
| Rail | 3,223 | 6,531 | 7,276 | 7,481 | 8,466 | 9,222 |
| Air | 124 | 12 | 1 | 149 | 19 | 31 |
| Other | | | | 95 | 121 | |
| Total | 65,510 | 69,575 | 69,781 | 77,876 | 88,212 | 114,789 |

*Source: Statistics Canada, 1986.*

are generally under long term lease. Water shipment is now a major means of cement distribution in Ontario. Lafarge Canada, Lake Ontario Cement, and St. Lawrence Cement operate fleets of specialized cement carriers to move product from their plants at Bath, Picton, and Clarkson to terminals in Ontario and the United States. Lafarge Canada at Woodstock has used specialized barges and trailers to move cement via Port Stanley on Lake Erie to its US customers. St. Marys Cement in Bowmanvile has recently constructed a dock, for handling inbound shipments of coal and gypsum, that has the capability of handling outbound shipments of cement. Prior to the construction of the dock the Bowmanville plant used the nearby port facilities in Oshawa to load cement. Bulk shipments from St. Marys Cement in St. Marys and Federal White Cement in Woodstock are by truck and rail, with truck shipments predominating. All of the cement plants have facilities for the packing and shipment of cement in bags, which now, however, represent a small proportion of the shipments for all of the companies, generally less than 10%.

The relative importance of water transport in Ontario's cement industry is illustrated in Table 4.14 and Table 4.15. Out of total cement production of 4,043,742 tonnes in 1985 1,452,734 tonnes, or 36% was moved by water. For some companies such as Lake Ontario Cement water shipment is the principal transportation mode. In 1985 the company shipped approximately 80% of production by water.

Water is the principal means of transport for cement exports from Ontario, with 974,675 tonnes or 90% of the total 1985 Ontario exports of 1,085,000 tonnes of cement being moved by water. However, as can be seen from Table 4.15, road transport has now become the dominant mode of shipment in terms of value of exports. This shift in the relative importance of water and road is indicative of increased exports of higher value-added concrete products.

# Lime, Chemical and Metallurgical Stone

## LIME

### ONTARIO LIME PRODUCTION

Ontario–based producers of lime are listed in Table 4.16. Some lime is also recovered by pulp and paper mills during the recausticization process to recover the spent pulping liquor in sulphite pulp mills. Of the eight major lime producers in the province three operate totally captive plants while two operate combined captive and merchant plants. Stelco Inc. in Ingersoll and Dofasco Inc. (BeachviLime Ltd. and Guelph DoLime Ltd.) produce lime for their own use and for commercial sale; General Chemical Canada Ltd. operates a lime plant as part of its sodium carbonate, calcium chloride, and hydrofluoric acid production operations in Amherstburg; Timminco Ltd. calcines a high purity dolomite for use in the production of magnesium metal by the Pidgeon process at Haley; Algoma Steel Corp. Ltd. produces lime for use in its iron and steel making operations at Wawa and Sault Ste. Marie; Reiss Lime Company of Canada Ltd. operates a lime plant at Spragge on Georgian Bay, though it imports almost all of its stone requirements from quarries in Michigan; and Steetley Industries Ltd. produces dolomitic lime for use in the steel and glass industries at its plant in Dundas.

Figure 4.16 and Figure 4.17 illustrate changes in the production of lime in Canada and Ontario. Quicklime represents over 90% of total lime production in any given

**Table 4.16. ONTARIO LIME PRODUCERS.**

| | | |
|---|---|---|
| Algoma Steel Corp. Ltd. | Sault Ste. Marie | High calcium and dolomitic captive use |
| General Chemical Canada Ltd. | Amherstburg | High calcium captive use |
| BeachviLime Ltd. | Beachville | High calcium captive and market |
| Guelph DoLime Ltd. | Guelph | Dolomitic (quick and hydrated) captive and market |
| Timminco Ltd. | Haley | Dolomitic captive use |
| Reiss Lime Co. of Canada Ltd. | Spragge | High calcium market |
| Stelco Inc. | Ingersoll | High calcium captive and market |
| Steetley Industries Ltd. | Dundas | Dolomitic market |

*BeachviLime and Guelph DoLime are subsidiaries of Dofasco Inc.*

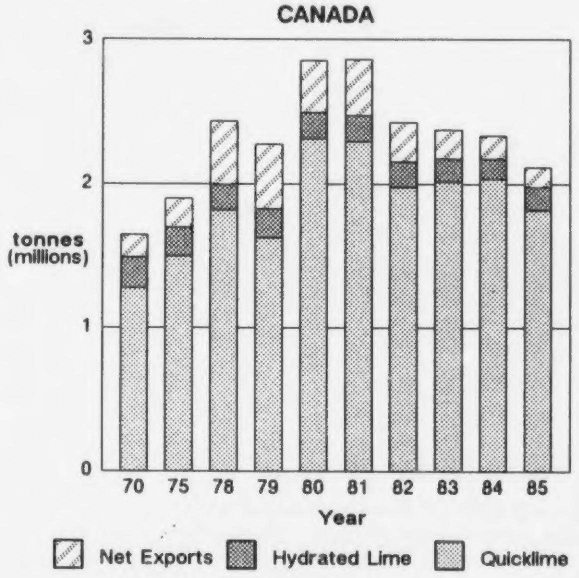


**Figure 4.16. CANADIAN LIME PRODUCTION.** *Source: Canadian Minerals Yearbook, 1986.*

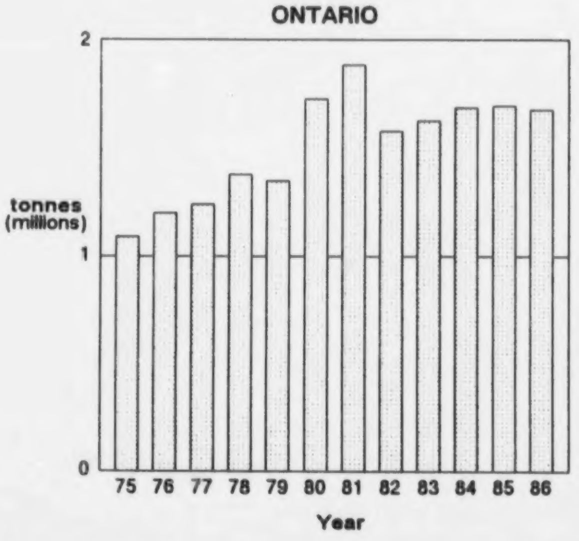


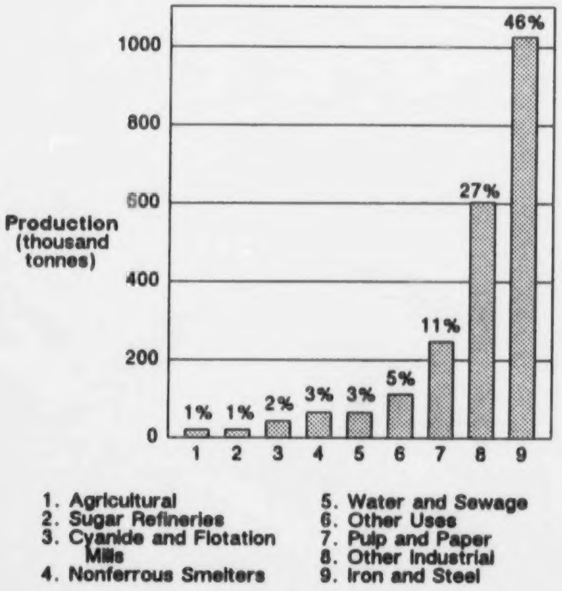
**Figure 4.17. ONTARIO LIME PRODUCTION.** *Source: Canadian Minerals Yearbook, 1986.*

year. Ontario production represents 70%–75% of total Canadian production, and is the principal source of lime exports. Almost all exports and imports of lime are connected with trade with the United States. There are no data available regarding dolomitic lime production. Production capacity for lime in Canada totals approximately 12,000 tonnes per day and, assuming an average availability of 330 days, total annual lime production capacity is approximately 3.96 million tonnes. These data indicate that Canadian lime producers have considerable excess production capacity and have experienced operating rates of 50%–55% in recent years. Most of the excess capacity is located in Ontario.

## LIME CONSUMPTION

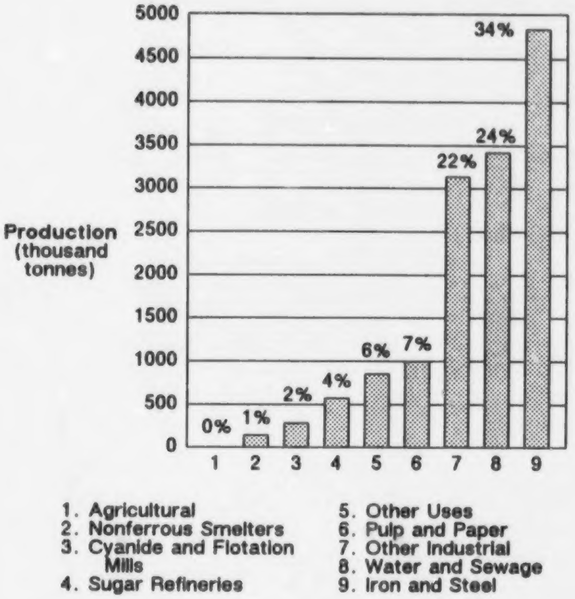
Figure 4.18 and Figure 4.19 detail lime consumption in Canada and the United States, and show a greater diversity of use in the US. The much greater use of lime in the US for environmental and soil stabilization purposes is especially noticeable. Factors affecting the use of lime in Canada include the following:

- Phase–out of open hearth steel production in favour of BOF and EAF steel production. By the end of 1989 there will be no open hearth steel furnaces in operation in Canada. Lime consumption will increase at the expense of limestone consumption in the steel industry.



1983 Consumption: 2,232,000 tonnes

**Figure 4.18.** CANADIAN LIME CONSUMPTION. *Source: Canadian Minerals Yearbook, 1986.*



1985 Consumption: 14,254,000 tonnes

**Figure 4.19.** UNITED STATES LIME CONSUMPTION. *Source: US Bureau of Mines Minerals Yearbook, 1985.*

- Significantly less use of flue gas scrubbers for desulphurization in Canada than in the United States;
- Significantly lower levels of industrial and municipal waste water treatment in Canada than in the United States;
- Rapid expansion of mechanical pulping technologies to replace chemical pulping, thus reducing the demand for lime.

The most significant factor affecting demand for lime is expected to be the imposition of much more stringent air pollution standards. Mandatory requirements for scrubbers to remove $SO_2$ and NOx emissions would require greatly increased lime production. An example of the potential impact of more stringent standards was provided in a study performed in the United States (Subhash, 1985). The study indicates complete installation of scrubbers on US thermal power plants would increase lime consumption by a factor of 4.9 to 13 times the level of use in 1982, depending upon the severity of the air quality standards. In the case of Ontario, removal of sulphur emissions from flue–gases would require approximately 500,000 tonnes of lime per year at current sulphur dioxide generation levels. Figure 4.20 provides a forecast of Ontario lime production to 1996. The forecast indicates a slight reduction in production over the next several years. This reduction is attributable to

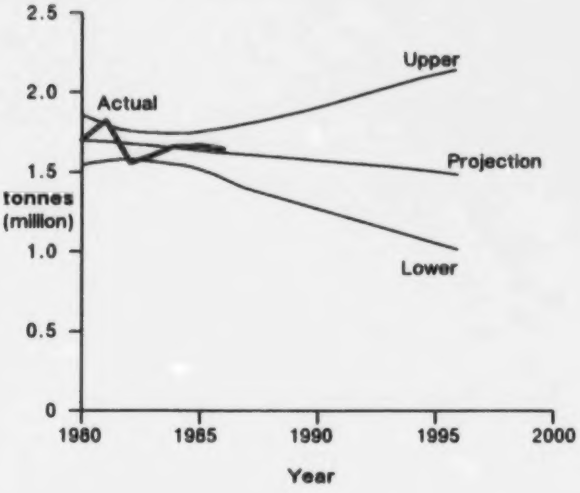


**Figure 4.20. ONTARIO LIME PRODUCTION FORECAST, DATA, PROJECTION AND 95% LIMITS.**

changes in lime demand from the major consuming industries such as the steel and pulp and paper mills, and to a levelling off in demand for lime for other chemical and metallurgical purposes. The upper projection assumes increased demand for lime for environmental purposes.

## PRICES

Prices for lime are a factor of market competition, end-use requirements, and transportation costs. In Canada average prices for quick and hydrated lime are shown in Table 4.17.

Significant variations in price by end-use and geographic area are common. For example, average lime prices declined from $69.20 per tonne in 1983 to $66.50 per tonne in 1985 in Ontario but remained stable in Alberta at $70.60 per tonne in 1983 and $70.25 per tonne in 1985. It is also known that producers located in areas providing a transportation barrier, such as New Brunswick, are able to secure significantly higher prices than producers in a more competitive market such as southern Ontario.

**Table 4.17. CANADIAN LIME PRICES.**

| | $/tonne | |
|---|---|---|
| | **Quicklime** | **Hydrated Lime** |
| 1982 | $63.63 | $76.38 |
| 1983 | 68.87 | 86.70 |
| 1984 | 68.75 | 86.13 |
| 1985 | 68.18 | n/a |

*Source: Energy, Mines and Resources Canada, 1986*

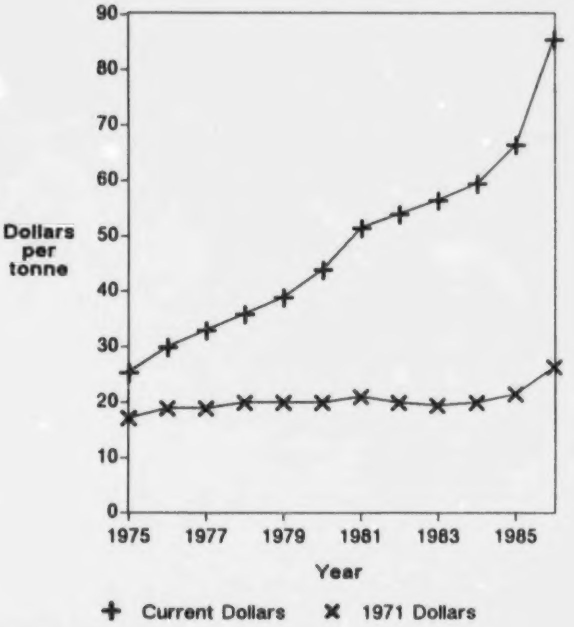


**Figure 4.21. ONTARIO LIME PRODUCTION, UNIT VALUE IN CURRENT AND 1971 DOLLARS.** *Source: "Ontario Mineral Score", Ontario Ministry of Northern Development and Mines, 1986.*

Figure 4.21 details Ontario lime prices. Prices have increased 10.7% per annum since 1975 in current dollar terms but only 5.5% per annum in constant 1971 dollar terms. The low level of real price increase and the excess capacity in the industry has not been conducive to major expansion and modernization projects. US prices for lime are listed in Table 4.18. The wide variation in price by end-use is noticeable.

## LIME PRODUCTION COSTS

Lime production is a highly energy intensive business. On average, Canadian lime producers use about 6.4 GJ of energy per tonne of production. Newer plants make use of preheater systems, energy efficient large diameter short rotary kilns, and modern vertical kiln designs to reduce fuel requirements. In Ontario average energy consumption per tonne of lime was 5.4 GJ (5.16 million Btu). There has been relatively little change in average energy consumption per tonne of product in recent years, as illustrated by Figure 4.22. The cost of energy, however, has increased significantly, and stood at

**Table 4.18. US LIME PRICES.**

| End-Use | (\$US/ton)<br>1984 | 1985 |
|---|---|---|
| BOF Steel | 46.02 | 49.80 |
| Water purification | 51.38 | 49.88 |
| Pulp & paper | 47.41 | 49.78 |
| Sewage treatment | 55.16 | 50.11 |
| Alkalis | 48.93 | 49.80 |
| Sugar refining | 67.86 | 49.87 |
| Road stabilization | 55.10 | 65.62 |
| Masons' lime | 63.68 | 65.59 |
| Refractory dolomite | 60.35 | 64.69 |
| Flue-gas desulphurization | 46.47 | 49.80 |
| Average for all lime | 51.12 | 51.69 |
| Average for quicklime | | 46.46 |
| Chemical lime | | 45.88 |
| Agriculture | | 49.02 |
| Construction | | 54.88 |
| Average for hydrated lime | | 67.56 |
| Chemical lime | | 65.96 |
| Agriculture | | 65.96 |
| Construction | | 69.32 |

*Source: US Bureau of Mines, Minerals Yearbook, Lime, 1985.*

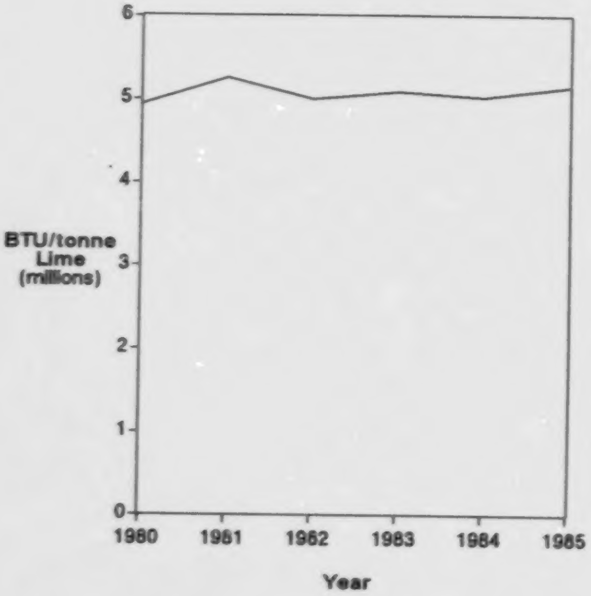


**Figure 4.22. ENERGY CONSUMPTION/TONNE OF LIME.** *Source: "Ontario Mineral Score", Ontario Ministry of Northern Development and Mines, 1986.*

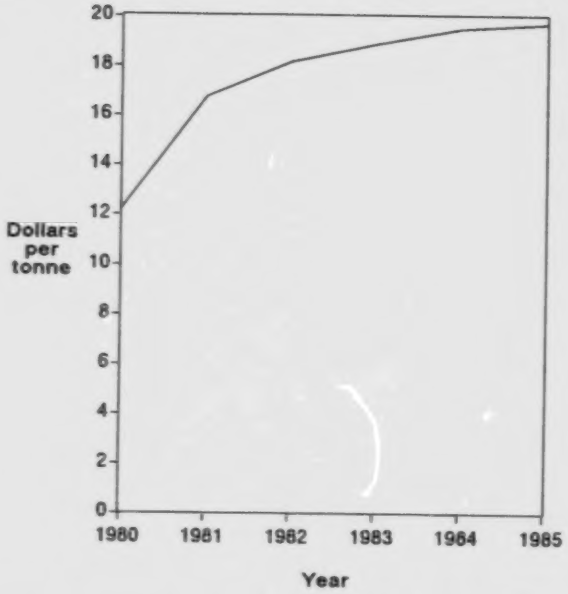


**Figure 4.23. ENERGY COST/TONNE OF LIME.** *Source: "Ontario Mineral Score", Ontario Ministry of Northern Development and Mines, 1986.*

\$19.70/tonne in 1985 versus \$12.24/tonne in 1980. This is illustrated in Figure 4.23.

In an effort to reduce fuel costs Ontario lime producers have switched to burning coal and coke and reduced their reliance on fuel oil. Coal and coke represented 48% of the energy requirements and 29% of the energy dollars in 1985, versus 18% of energy requirements and 11% of energy dollars in 1980. These changes are illustrated in Figure 4.24.

Total direct costs for lime production in Ontario have increased at a rate of 5.45% per annum during the 1980–1985 period. Prices have increased at a rate of 7.06% per annum during the same period. The distribution of direct production costs has remained stable at 54% for energy in 1980 and 1985; 25% and 23% for wages; and 21% and 23% for supplies in 1980 and 1985 respectively, as shown in Figure 4.25.

## CHEMICAL PROCESS STONE

Chemical process stone refers to limestone and dolostone used in the production of various chemicals. It is distinguished from lime used for similar purposes in that chemical stone is used directly rather than separately calcined first. The principal end-use markets for chemical process stone in Ontario are the glass industry, the pulp and paper industry, and in soda ash manufacture. Minor amounts of stone are used in paint manufacture.

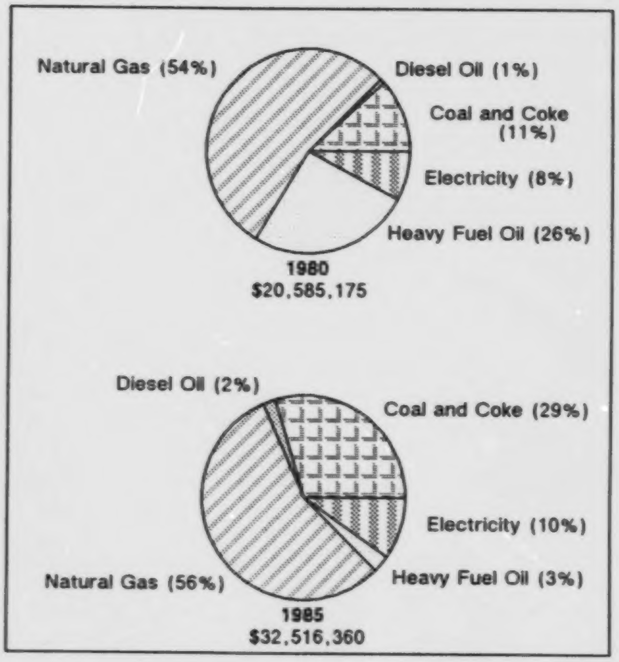


**Figure 4.24. ENERGY COST/TONNE OF LIME.** *Source: "Ontario Mineral Score", Ontario Ministry of Northern Development and Mines, 1986.*

## GLASS MANUFACTURE

Crushed limestone and dolostone are used in glass manufacture to make the glass more insoluble. Limestone and dolostone used in glass manufacture must be low in iron, at least below 0.06% FeO.

Consumption of limestone and dolostone in the Canadian glass industry in recent years is given in Table 4.19.

Ontario glass plants were reported to have used 128,553 tonnes of Ontario limestone and dolostone in 1984 and 149,143 tonnes in 1985.

## PULP AND PAPER

Pulp and paper mills use limestone as supplementary material to make up their lime requirements for the recausticization of the spent sulphite pulping liquor. Requirements are modest and vary from year to year depending on the performance of the kiln and the relative costs of lime and limestone. Very limited amounts of magnesia or dolostone are used in sulphite pulp mills to prepare magnesium sulphite. The total Canadian limestone and magnesia requirements in recent years are given in Table 4.20.

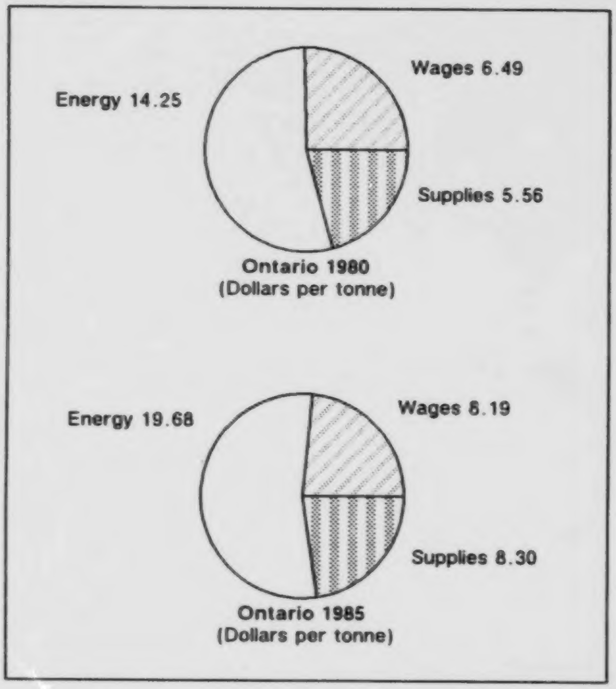


**Figure 4.25. COSTS OF LIME PRODUCTION.** *Source: "Ontario Mineral Score", Ontario Ministry of Northern Development and Mines, 1986.*

## SODA ASH (SODIUM CARBONATE) MANUFACTURE

High calcium limestone is used in the production of soda ash by the Solvay process, though this has largely been supplanted by the use of natural soda ash, named trona, from Wyoming. There is only one Canadian producer of soda ash, General Chemical Canada Ltd. (formerly Allied Chemical Canada Ltd.) in Amherstburg, and only one remaining US producer. General Chemical produces calcium chloride, sodium bicarbonate, and a range of

**Table 4.19. LIMESTONE AND DOLOSTONE CONSUMPTION IN THE GLASS INDUSTRY.**

| | Limestone | Dolostone |
|---|---|---|
| | ('000 tonnes) | |
| 1979 | 176.2 | n/a |
| 1980 | 173.3 | n/a |
| 1981 | 176.1 | n/a |
| 1982 | 168.7 | n/a |
| 1983 | 175.9 | n/a |
| 1984 | 178.0 | 112.0 |
| 1985 | 138.0 | n/a |

Source: Statistics Canada, 1986

**Table 4.20. LIMESTONE AND DOLOSTONE CONSUMPTION IN THE PULP AND PAPER INDUSTRY.**

| | Limestone | Magnesia |
|---|---|---|
| | (tonnes) | |
| 1980 | 25,560 | 7,496 |
| 1981 | 22,658 | 9,330 |
| 1982 | 97,372 | 4,584 |
| 1983 | 114,671 | 2,109 |
| 1984 | n/a | n/a |
| 1985 | n/a | n/a |

Source: Statistics Canada, 1986

**Table 4.21. STEEL INDUSTRY LIME CONSUMPTION, CANADA/UNITED STATES.**

| | (tonnes) | |
|---|---|---|
| **Canada** | 1983 | 1984 |
| Quicklime | 325 511 | 329 214 |
| Other lime | 205 802 | 242 522 |
| Limestone | 980 000 | |
| **United States** | 1984 | 1985 |
| Limestone | 3 481 973 | 3 689 676 |
| Dolostone | 64 850 | 19 047 |
| Burnt lime | 3 036 636 | 2 696 511 |
| Other | 243 983 | 175 051 |

*Source: Statistics Canada, 1985*
*US Bureau of Mines, Minerals Yearbook, 1985.*

**Table 4.22. ONTARIO MAGNESIUM AND CALCIUM PRODUCTION.**

| | Magnesium | | Calcium | |
|---|---|---|---|---|
| Year | ('000 kg) | ($ 000) | ('000 kg) | ($ 000) |
| 1978 | 8,311.2 | 20,155.4 | 574.8 | 2,397.5 |
| 1979 | 9,015.0 | 24,444.0 | 455.7 | 2,152.1 |
| 1980 | 9,252.0 | 27,821.8 | 530.6 | 3,421.6 |
| 1981 | 8,548.0 | 29,439.5 | 469.4 | 4,512.1 |
| 1982 | 7,630.2 | 27,811.9 | 329.1 | 2,567.3 |
| 1983 | 5,980.3 | 21,978.1 | 398.9 | 3,306.5 |
| 1984 | 7,587.5 | 30,926.7 | 515.4 | 4,559.6 |
| 1985 | 8,446.3 | 36,369.6 | 738.5 | 7,778.9 |

*Source: "Ontario Mineral Score", Ontario Ministry of Northern Development and Mines, 1986.*

other calcium and sodium compounds or by-products and co-products of the Solvay process. Production is sold in Canada and the mid-western US. Stone requirements were reported to be over half a million tonnes in 1984 and 1985.

## METALLURGICAL STONE

Crushed limestone and dolostone are used as a flux in ferrous and non- ferrous smelting and refining as a cheap substitute for the more expensive lime. The crude crushed material is also preferred for technical reasons in some applications. Table 4.21 illustrates changes in the demand for limestone and dolostone in the US and Canadian iron and steel industries in recent years.

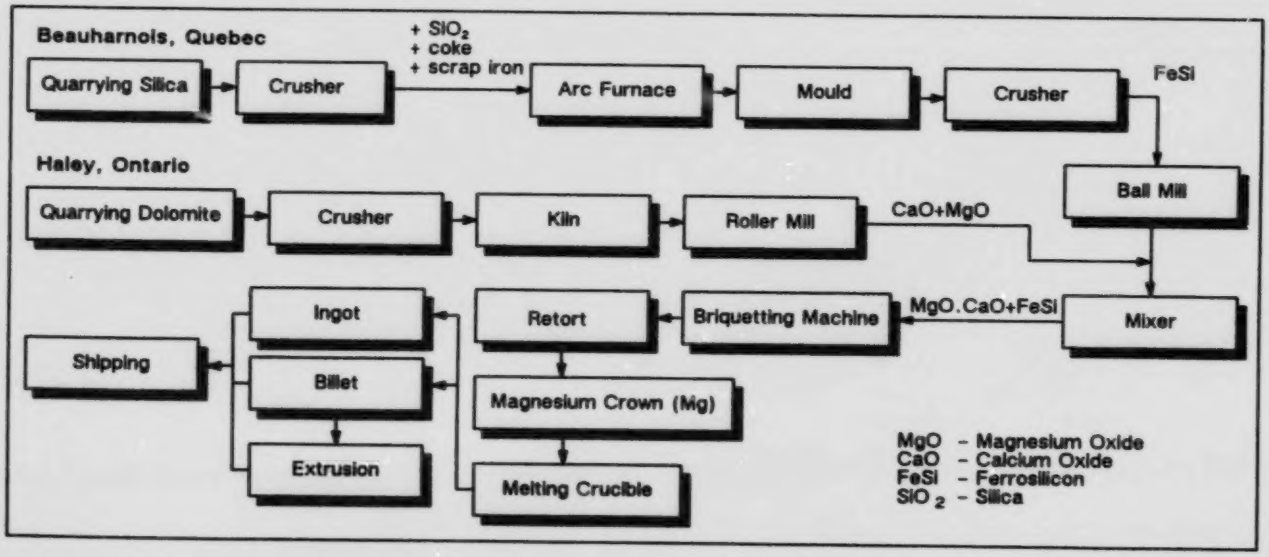

Beauharnois, Quebec
Quarrying Silica
Crusher
+ $SiO_2$
+ coke
+ scrap iron
Arc Furnace
Mould
Crusher
FeSi
Haley, Ontario
Quarrying Dolomite
Crusher
Kiln
Roller Mill
CaO+MgO
Ball Mill
Mixer
MgO.CaO+FeSi
Briquetting Machine
Retort
Magnesium Crown (Mg)
Melting Crucible
Ingot
Billet
Extrusion
Shipping
MgO - Magnesium Oxide
CaO - Calcium Oxide
FeSi - Ferrosilicon
$SiO_2$ - Silica

**Figure 4.26. MAGNESIUM PRODUCTION AT TIMMINCO LTD. USING PIDGEON PROCESS.** *Source: company literature.*

Limestone and dolostone are also used in non-ferrous smelting, but the quantities employed are relatively low, as lime is the primary flux. Actual usage depends on the relative delivered costs of stone and lime. Ontario production of stone for this purpose was reported to be 143,605 tonnes in 1984 and 149,143 tonnes in 1985.

Magnesium and calcium metal production is the other major metallurgical market for dolostone and high calcium limestone. Timminco Ltd. produces both metals using a variant of the alumino-silicothermic Pidgeon process at its plant at Haley, Ont. The Pidgeon process is illustrated in Figure 4.26.

Timminco recovers magnesium from a high quality Precambrian dolomitic marble quarried on site; calcium from high calcium stone obtained from quarries in southern Ontario; and strontium from imported celestite.

Dolomitic marble requirements for magnesium production were 106,267 tonnes in 1984 and 109,257 tonnes in 1985. Data on magnesium and calcium metal production are provided in Table 4.22. Timminco has announced plans to increase magnesium production capacity to approximately 15,000 tonnes per year from the current level of 10,000 tpy.

# Fillers and Extenders

## MARKETS

The principal end–use markets for calcium carbonate fillers are in plastics, paint, paper, adhesives and sealants, rubber, drywall compounds, and carpet backing.

### PLASTICS

The relative growth rates of resin and fillers for the 1976–1985 period in the United States are illustrated in Figure 4.27. As shown, resin production increased 5.2% per annum during the 1980–1985 period. During the same period, the consumption of fillers and reinforcing materials in polymer–based materials increased at an average annual rate of 8.9%. Calcite itself exhibited an average annual growth rate of 10.4% during the 1980–1985 period in the US. The rapid growth rates for fillers are expected to continue for the next several years.

Calcium carbonate is by far the main filler used in plastics, and represents approximately 50% of the market for all mineral fillers and reinforcements. C.H. Kline and Co. estimates that carbonate fillers accounted for 662,200 tonnes of the 1,452,000 tonnes of mineral reinforcements and fillers used by the US plastics industry in 1986.

The most important plastics markets for calcium carbonate are PVC and thermosetting polyesters. Of the total volume of 662,200 tonnes of calcium carbonate consumed in plastics in 1986 in the US approximately 65%, or 430,900 tonnes, was used in PVC. Polyesters accounted for a further 30%, or 198,700 tonnes. The balance of approximately 32,700 tons was used in other plastics such as polypropylenes, polyurethanes, ABS, and phenolics. Data on consumption patterns is provided in Table 4.23.

Calcium carbonate consumption trends are expected to parallel the growth rates for the plastics.

Calcium carbonate in PVC is found in both flexible and rigid materials. The market for flexible PVC faces stiff competition from cheap offshore calendered vinyl producers and is not expected to show much growth.

Rigid PVC applications for calcium carbonate include pipe and mouldings, windows and doors, floor tile, etc. There is a push by some manufacturers to increase calcium carbonate loadings in pipe by up to 50%, but this will require changes in government specifications for pipe.

Polyesters have been the largest growth area for calcium carbonate in plastics, typical mineral reinforced polyester formulations containing 40% to 45% calcium carbonate by weight. The automobile industry is the principal end–user of these products, accounting for approximately 75% of the market, mainly for the front–end panels of cars (sheet moulding compound (SMC)) and truck

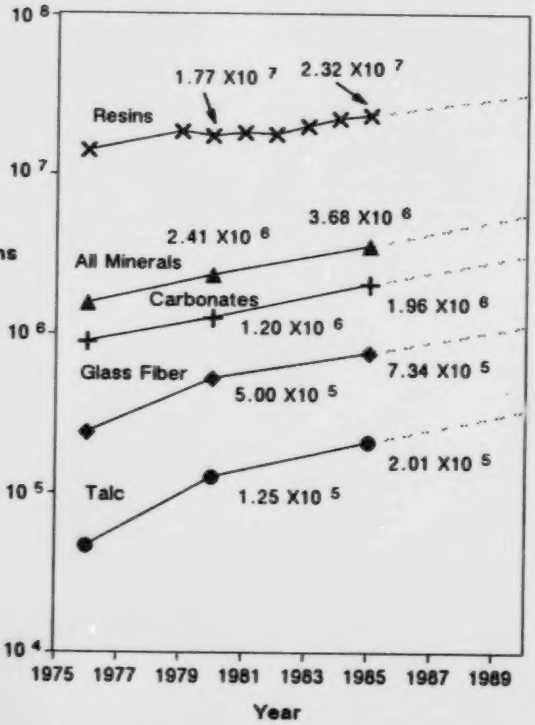


**Figure 4.27. US CONSUMPTION OF RESINS AND OF FILLER, EXTENDER AND REINFORCING MINERALS FOR POLYMER–BASED COMPOSITES (TONS).** *Source: Plumpton et al., (1987), Clifton, SME–AIME annual meeting, N.Y., Feb. 1985; Dickson, Industrial Minerals, Feb. 1987.*

**Table 4.23. CALCIUM CARBONATE CONSUMPTION IN PLASTICS, UNITED STATES.**

| | (tonnes) | |
|---|---|---|
| | 1983 | 1986 |
| PVC | 268 000 | 431 000 |
| Polyesters | 100 000 | 199 000 |
| Others | 18 000 | 33 000 |
| Total | 380 000 | 663 000 |

*Source: Industrial Minerals, various issues.*

hoods, fenders and front–end panels (bulk moulding compound (BMC)).

Calcium carbonate may also be used as a filler in other plastics; polypropylene is a major potential market, with calcium carbonate as a low cost replacement for talc.

### PAINTS

Calcium carbonate is used as an extender in oil, alkyd, acrylic, and latex– based paint systems. The US paint industry consumed approximately 222,200 tonnes of carbonate fillers in 1983. The market is characterized by slow growth, although recent technological developments related to product form and particle size may increase the level of use.

### PAPER

Calcium carbonate for use as a filler and coating material in paper manufacture is a relatively new development, with a potential annual market available in excess of 450,000 tonnes in North America. In particular, the market has been opened up by the switch from acid sizing to alkaline sizing, permitting the use of calcium carbonate as the filler material.

The overall cost advantages of alkaline sizing are estimated at approximately $20.00 per tonne. Despite the cost advantages, alkaline sizing is still not widely used in North American paper mills, although its use is increasing.

### PUTTY, CAULKS, AND SEALANTS

Calcium carbonate is widely used as a filler for putty, caulks, and sealants. Consumption in the US in 1983 amounted to approximately 113,000 tonnes.

### RUBBER

Calcium carbonate fillers are used in soft rubber goods such as floor coverings and auto mats. Kaolin is the primary filler with calcium carbonate used as a supplement to reduce product cost. Calcium carbonate fillers may also be used in wire and cable coatings, automotive weather stripping, and some footwear applications.

### CARPET BACKING

Carpet backing is the largest volume application for calcium carbonate, consuming about 475,000 tonnes in 1983 in the US.

### JOINTING COMPOUNDS

Calcium carbonate is used as a filler in drywall jointing compounds and in 1983 approximately 445,000 tonnes were used in this application in the United States.

## PRICES

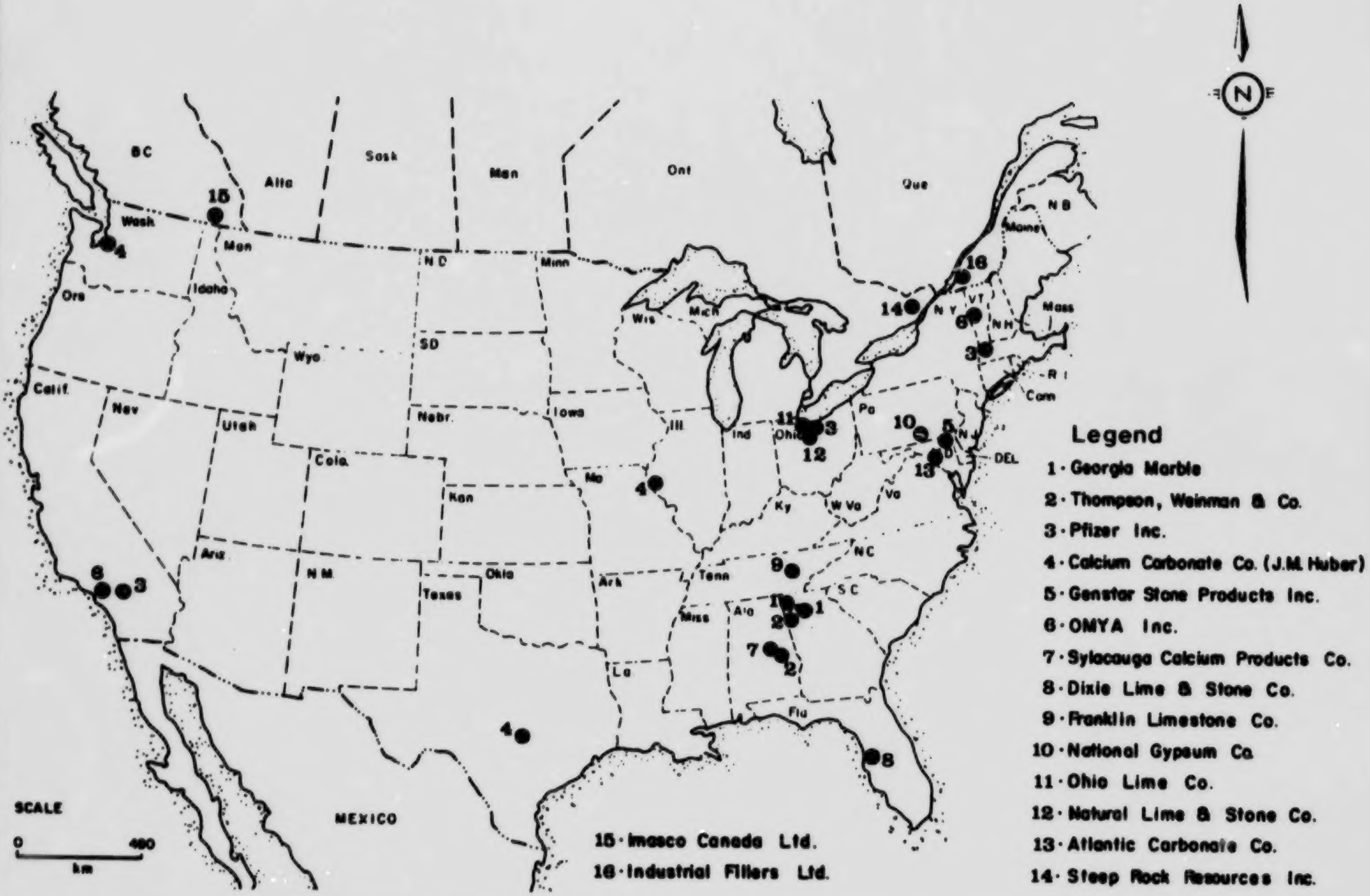
Prices for various grades of calcium carbonate are listed in Table 4.24. The prices listed show that there is considerable value–added as the fineness of the product increases and as other treatments such as surface coatings are incorporated in the products. Increasing the fineness of the material from an average particle size of 4 to 9 microns to one of 0.5 to 4 microns adds approximately 66% to the price of the product; manufacture of an ultrafine grade in slurry form will yield more than double the price of the medium grind product; while coated ultrafine calcium carbonates are worth approximately 4.5 times the value of a standard 325 mesh (44 micron) product. The increased value associated with the production of ultrafine grind and surface treated calcium carbonates is an obvious attraction. Nevertheless, there are only a few North American producers of ultrafine grind calcium carbonates, and no producers of surface treated calcium carbonates in Canada.

Prices for calcium carbonate fillers and extenders are generally quoted on an FOB producer basis. Accordingly, transportation costs can play a major role in determining the market opportunities available to a producer. Figure 4.28 illustrates the location of producers of fine grind (below 325 mesh, 44 micron) calcium carbonate as of 1984, and shows most of them to be concentrated in the eastern part of North America. Freight costs from producing plants to consumers may offset the advantages

**Table 4.24. CALCIUM CARBONATE PRICES, NEW YORK BASIS.**

| | ($US/ton), May 1987 |
|---|---|
| Dry, coarse (9–17 microns), 325 mesh, bags or bulk, fob works | $49.00 - $90.00 |
| medium (4–9 microns) | 70.00 - 100.00 |
| fine (0.5–4 microns) | 123.00 - 166.00 |
| Slurry, fine (2–4 microns) | 125.00 - 139.00 |
| ultrafine | 166.00 - 177.00 |
| Coated, fine (2–3 microns) | 167.00 |
| ultrafine (1 micron) | 228.00 |
| Precipitate, technical (0.5 microns) | 212.00 - 217.00 |
| ultrafine (0.05–0.5 microns) | 540.00 |
| surface treated | 320.00 |
| USP, very fine, high purity | 385.00 - 400.00 |
| extra light | 395.00 |
| light to medium | 400.00 |
| heavy | 445.00 |

*Source: Chemical Market Reporter, May 29, 1987.*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MEXICO
SCALE
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km
Legend
1 · Georgia Marble
2 · Thompson, Weinman & Co.
3 · Pfizer Inc.
4 · Calcium Carbonate Co. (J.M. Huber)
5 · Genstar Stone Products Inc.
6 · OMYA Inc.
7 · Sylacauga Calcium Products Co.
8 · Dixie Lime & Stone Co.
9 · Franklin Limestone Co.
10 · National Gypsum Co.
11 · Ohio Lime Co.
12 · Natural Lime & Stone Co.
13 · Atlantic Carbonate Co.
14 · Steep Rock Resources Inc.
15 · Imasco Canada Ltd.
16 · Industrial Fillers Ltd.

**Figure 4.28.** LOCATION OF PRODUCERS OF FINE-GROUND CALCITIC AND DOLOMITIC CARBONATE. *Source: Guillet And Kriens, 1984.*

**Table 4.25. CANADIAN CALCIUM CARBONATE DEMAND.**

| | | | (tonnes) | | |
|---|---|---|---|---|---|
| | **1980** | **1981** | **1982** | **1983** | **1984** |
| Pulp & Paper | 1,660 | 45,018 | 18,928 | 4,473 | n/a |
| Paint | 30,968 | 22,318 | 18,669 | 22,190 | 18,532 |
| Rubber ($M) | 1,028 | 1,296 | 1,237 | 1,561 | n/a |
| Asphalt Filler | n/a | n/a | 31,000 | 33,000 | n/a |
| Plastics | n/a | n/a | n/a | n/a | n/a |

*Source:* *Statistics Canada, 1985.*

of using a higher quality product in some markets. For example, material from deposits in Maryland and Vermont generally has a 3 to 5 GE brightness advantage over material from the area around St. Louis. Despite this quality advantage, paint producers in the the Midwest prefer to use local calcium carbonate due to its lower delivered cost. Adjustment of pigment levels to overcome the brightness differential is less costly than using the higher quality stone.

## CANADIAN DEMAND

Demand for calcium carbonate fillers in Canada has been estimated at approximately 150,000 tonnes for 1983. Domestic production has been estimated at 125,000 tonnes, with exports of 25,000 tonnes and imports of 50,000 tonnes. Data on end–use consumption are incomplete, and reliable market volume determinations are difficult to make. Table 4.25 provides some limited information on the demand for calcium carbonate in some of the principal end–use markets.

## CANADIAN DEVELOPMENTS

Significant Canadian developments related to the supply of calcium carbonate fillers include the following:

- Expansion of the Steep Rock Calcite plant at Perth to include production of ultrafine grind products using wet grinding technology. This is a joint venture with Georgia Kaolin of the United States.
- Development of a fine grind calcium carbonate plant by Calcite et Dolomie de Mattawin in Quebec.
- Development of a calcite filler plant by Calcite du Nord in Quebec.

Canadian production capacity for standard and medium grind calcium carbonate filler grades would appear to be sufficient at present. Canadian capacity and demand for production of ultrafine grind grades still indicates room for expansion. As there is no domestic capacity for the supply of surface treated ultrafine grind calcium carbonates, there would appear to be an obvious opportunity for enhanced value added.

# Building Stone

## BUILDING STONE MARKETS

Data for Ontario limestone building stone production for the 1981 to 1986 period is given in Table 4.26.

**Table 4.26. PRODUCTION OF LIMESTONE BUILDING STONE.**

| | Production (tonnes) | Value ($) | $/Tonne |
|---|---|---|---|
| 1981 | 277,291 | 1,234,326 | 4.45 |
| 1982 | 130,112 | 998,022 | 7.67 |
| 1983 | 141,322* | 1,214,209* | 8.78 |
| 1984 | 154,084* | 1,578,594* | 10.24 |
| 1985 | 168,023 | 1,787,186 | 10.64 |
| 1986 | 198,847 | 2,424,339 | 12.19 |

Source: Ontario Ministry of Northern Development and Mines.
*Estimated figures.

The significant increase in value in recent years is attributed to the strong demand for building stone facing on commercial and multi–unit residential developments. In addition, Ontario stone has been used for several large institutional projects such as the new Canadian embassy in Washington D.C. Part of the increase in value results from the development of new technology for the bonding of limestone veneers to pre–cast concrete panels. This allows the stone plant to produce a very high value–added product, yet one which remains competitive with other building systems.

The market for building stones has traditionally been limited by transportation charges. Until very recently, relatively little building stone was shipped out of the province. For example, in 1980 92.5% of the stone was used in Ontario. This increased to 98.8% in 1981 and stood at 91% in 1982. In 1984 and 1985, however, Ontario accounted for only 81.5% and 66.6%, respectively, of building stone shipments.

Quebec and the United States represent the most significant destinations for Ontario building limestone. In 1985 3,220 tonnes were shipped to Quebec and 1,130 tonnes to the US.

It is expected that markets for building stone, especially for commercial use, will increase in the next few years as architects reacquaint themselves with the material and more modern production technology is installed by the stone producers. Another factor contributing to the growth in the market will be restoration of many of Ontario's historic limestone buildings and public structures such as the Rideau Canal. These trends may help to restore Ontario's limestone industry to the status it once enjoyed as a major source of building materials.

The potential for building stone from Grenville marble in Southeastern Ontario has been discussed by Verschuren et al. (1985), who emphasize that attempts should be made to develop markets for unique Ontario stones rather than to reproduce popular European marbles.

# Pulverized Stone and Stone Chips

## TERRAZZO CHIPS

The production of terrazzo chips in Ontario was started by Carl Stoklosar in the early 1930s, using a small jaw crusher and screen mounted on the back of a truck, at a site east of Eldorado. In 1935 he took over an old slate mill which had operated in the 1920s on the east side of Highway 62 several kilometres north of Madoc, and this is still the main plant site for Stoklosar Marble Quarries Ltd. Two other terrazzo producers subsequently commenced production at Madoc: Hastings Marble Products Ltd. and Madoc Marble Quarries Co. (Hewitt, 1964, p.12), and these were merged in 1965 to form Grenville Aggregate Specialities Ltd. The sale of white Grenville dolomite chips for terrazzo was also started about this time from the nearby underground mine of Canada Talc Industries Ltd. Grenville Aggregates continued to operate the Hastings plant on old Highway 7 on the west fringe of Madoc village, and in 1983 the company merged with Stoklosar. In 1986 both plants were still being operated by Stoklosar Marble Quarries Ltd., currently the only significant producer of terrazzo chips in Ontario.

Domus Engineering Company of Toronto is the exclusive sales agent for Stoklosar products in Canada. Sales in the United States, which once accounted for 40 percent of the company's volume but now only 5 percent, are made directly from Madoc. Prices quoted in 1986 were:

| Products | Price |
|---|---|
| 0, 1, 2 | $160 per ton in 50 lb. plastic bags |
| 0, 5, 2 | $150 per ton in 100 lb. plastic bags |
| 3, 5, 7 | $165 per ton in 100 lb. plastic bags |
| All chip sizes | $120 per ton in bulk |
| White dust | $75 per ton in bulk |
| Coloured dust | $60 per ton in bulk |

It is interesting to note that the 1965 price for a 100 lb. bag of chips was 83 cents; the 1986 price was $7.50. Sales in 1965 were about 5,000 tons, but were significantly less in 1986. Twelve men are employed, and their wages represent more than half of total operating costs.

## WHITE MARBLE CHIPS

White marble chips were produced in Ontario by three companies in 1986. Steep Rock Resources Inc. produced a range of chip products at its Perth plant, using coarse grained calcitic marble from its Tatlock quarry. Bolenders Ltd. produced chips from its coarse-grained dolomitic marble at Eagle Lake near Haliburton, and Canada Talc Industries Ltd. produced fine-grained dolomitic marble chips from its talc mine at Madoc, principally for terrazzo. Other recent producers, currently dormant, are mentioned by Hewitt and Vos (1972, p.6) and Hewitt (1964, p.12).

Annual consumption within reach of Ontario producers is in the order of 50,000 tonnes, most of it in neighbouring US states as far west as Chicago. Ontario producers enjoy about half of this market, much of the rest being supplied by Georgia Marble Company from a quarry in northern New York State. Value of the chips in bulk FOB producing plant is about $20–25 per tonne.

The market for exposed aggregate is very much dependent on prevailing fashions in architecture. In 1986, North American demand was probably in the order of 10,000 tonnes.

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# Appendices

# Appendix I
# Glossary Of Geological Terms

Note: The following terms were referenced from: Bates and Jackson (1980) and American Geological Institute (1976).

*anhydrite:* A mineral, $CaSO_4$, anhydrous calcium sulfate. Orthorhombic, commonly massive in evaporite beds.

*argillaceous:* Rocks or substances composed of clay minerals, or having a notable proportion of clay in their composition, such as shale, slate, etc.

*ball-and-pillow structure:* A primary sedimentary structure found in sandstone and some limestones characterized by hemispherical or kidney-shaped masses resembling balls and pillows.

*basement:* 1) The undifferentiated complex of rocks that underlies the rocks of interest in an area. 2) The crust of the earth below sedimentary deposits, extending downward to the Mohorovicic discontinuity. In many places the rocks of the complex are igneous and metamorphic and of Precambrian age, but in some places are Paleozoic, Mesozoic, or even Cenozoic.

*bedding plane:* In sedimentary or stratified rocks, the division planes which separate the individual layers, beds, or strata.

*bedding:* A collective term signifying existence of beds or laminae. Planes dividing sedimentary rocks of the same or different lithology.

*bedrock:* A general term for the rock, usually solids, that underlies soil or other unconsolidated, superficial material.

*bioclastic rock:* A sedimentary rock consisting of fragmental or broken remains of organisms, such as limestone composed of shell material.

*bioherm:* A mound-like or circumscribed mass built exclusively or mainly by sedentary organisms such as corals, stromatoporoids, algae, etc., and enclosed in normal rock of different lithologic character.

*biostrome:* A bedded structure composed of shell beds, crinoid beds, coral heads, etc., which was built by sedentary organisms grown and preserved in place. In contrast to bioherms they lack mound-like or lens-like form.

*bioturbation:* The churning and stirring of a sediment by organisms.

*birdseye:* (Texture) Microcrystalline to very fine-crystalline limestone containing spots or tubes of crystalline calcite.

*bitumen:* A general name for various solid and semi-solid hydrocarbons which are soluble in carbon bisulfide, whether gases, easily mobile liquids, viscous liquids or solids. The term is often used interchangeably with hydrocarbons.

*bituminous:* 1) Yielding bitumen, or having bitumen in composition. This term is also commonly used for certain varieties of coal which burn freely with flame, although they really contain no bitumen. 2) Containing much organic or at least carbonaceous matter, mostly in the form of tarry hydrocarbons which are usually described as bitumen. 3) Having the odour of bitumen.

*bivalve:* A common term for pelecypods.

*Brachiopoda:* A phylum of marine, shelled animals with two unequal shells or valves, each of which normally is bilaterally symmetrical. Also called lamp shells.

*breccia:* Fragmented rocks whose components are angular and therefore, are distinguished from conglomerates, and are not water-worn. A rock made up of highly angular fragments. May be sedimentary or formed by crushing or grinding along faults.

*Bryozoa:* Phylum of small colonial animals, equipped with a lophophore, and that build calcareous structures of many kinds, mostly marine.

*burrow:* A cylindrical or near cylindrical tube, often filled with clay or sand, which may lie along the bedding plane or penetrate the rock, made by an animal that lived in the sediment.

*calcarenite:* A deposit composed of cemented sand-size grains of calcium carbonate ($CaCO_3$); usually a biosparite or a grainstone.

*calcilutite:* A name for limestone and dolostone made up of calcareous rock flour, the composition of which is typically nonsiliceous, though many calcilutites have an intermixture of clayey material. Grains or crystals average 0.0625 mm in diameter.

*calcisiltite:* Limestone composed of calcareous sediment of silt size.

*calcite:* A mineral, $CaCO_3$, hexagonal, rhombohedral, trimorphous with aragonite and vaterite; the principal constituent of limestone.

*carbonatite:* Intrusive carbonate rock which are associated with alkaline, igneous intrusions in many localities.

*celestite:* A mineral, $SrSO_4$. Orthorhombic. The principal ore of strontium.

*Cephalopoda:* Most highly developed class of mollusks that swam by ejecting a jet of water from the mantle cavity through a muscular funnel. Most of those preserved as fossils had straight to symmetrically coiled shells divided into chambers by transverse septa.

*chalk:* A very soft, white to light grey, unindurated limestone composed of the tests of floating microorganisms and some bottom dwelling forms in a matrix of fine–crystalline calcite. Usually siliceous.

*chert:* 1) Mineral: A cryptocrystalline variety of quartz. Composed of inter–locking grains generally not discernable under the microscope. 2) Rock: A compact siliceous rock of varying colour composed of microorganisms or precipitated silica grains. Occurs as nodules, lenses, or layers in limestones and shales.

*conchoidal:* A type of rock or mineral fractures giving smoothly curved surfaces. Characteristic of quartz and obsidian.

*conglomerate:* Rounded, water worn fragments of rock or pebbles, cemented together by another mineral substance. A cemented clastic rock containing rounded fragments corresponding in their grade sizes to gravel or pebbles.

*coquina:* Limestone composed of broken shells, corals, and other organic debris.

*coral, colonial:* A coral in which the individuals are attached together as a unit and do not exist as separate animals.

*coral:* A bottom–dwelling, sessile, marine coelenterate; some are solitary individuals, but the majority grow in colonies; they secrete external skeletons of calcium carbonate. The calcareous skeleton of a coral or group of corals.

*coralgal:* Refers to carbonate sediment derived from corals and algae.

*coralline:* Any organism that resembles a coral in forming a massive calcareous skeleton or base, such as certain algae or stromatoporoids. Pertaining to, composed of, or having the structure of corals, as coralline limestones.

*crenulations:* Wrinkles. Small folds, with a wavelength of a few millimetres.

*Crinoidea:* A type of echinoderm consisting of a cup or "head" containing the vital organs, numerous radiating arms, an elongate, jointed stem, and roots by which it is attached to the sea bottom while the body, stem, and arms float.

*cross–bedding:* The arrangement of laminations of strata transverse or oblique to the main planes of stratification of the strata concerned; inclined, often lenticular, beds between the main bedding planes.

*crystal:* A homogeneous, solid body of a chemical element, compound, or isomorphous mixture, having a regularly repeating atomic arrangement that may be outwardly expressed by plane faces.

*dolomite:* A mineral, $CaMg\ (CO_3)_2$, commonly with Fe replacing Mg to produce ankerite. Hexagonal rhombohedral. It occurs in a great many crystalline and noncrystalline forms in carbonate rock, and among rocks of all geological ages.

*dolostone:* The name for a sedimentary rock composed of fragmental, concretionary, or precipitated dolomite of organic or inorganic origin.

*eurypterid:* One of a group of very large, extinct arthropods related to the trilobites.

*fault:* A fracture or fracture zone along which there has been displacement of the sides relative to one another parallel to the fracture.

*fissility:* A property of splitting easily along closely spaced parallel planes.

*flame structure:* A load cast showing evidence of some horizontal slip. A load cast in which part of an underlying layer has been squeezed irregularly upward into the overlying layer.

*fossil:* The remains or traces of animals or plants which have been preserved by natural causes in the earth's crust.

*Gastropoda:* A class of the phylum Mullusca; commonly known as gastropods or snails.

*glauconite:* A green mineral, closely related to the micas and essentially a hydrous potassium iron silicate. Commonly occurs in sedimentary rocks of marine origin.

*gypsum:* A mineral, $CaSO_4\ 2H_2O$. Monoclinic. A common mineral of evaporites. Used in manufacture of plaster of Paris and drywall. Also called satin spar (fibrous gypsum).

*hematite:* A mineral, $Fe_2O_3$ hexagonal rhombohedral. The principal ore of iron.

*horn coral:* A solitary coral, conical in shape, and generally belonging to the subclass *Rugosa*.

*hydrocarbon:* A compound containing only the two elements carbon and hydrogen (see bitumen).

*inlier:* An area or group of rocks surrounded by rocks of younger age, e.g. an eroded anticlinal crest.

*interbedded:* Occurring between beds, or lying in a bed parallel to other beds of different material.

*interformational conglomerate:* Those gravels and their indurated equivalents that often are present within a formation of which the constituents have a source external to the formation.

*intraclast:* A broad, general term for a component of a limestone, representing a torn–up and reworked fragment of a penecontemporaneous sediment (usually weakly consolidated) that has been eroded within the basin of deposition (such as the nearby sea floor or an exposed carbonate mud flat) and redeposited there to form a new sediment.

*intraformational conglomerate:* A conglomerate, the clasts of which are derived from the formation of which the conglomerate is a part.

*joint:* Fracture in rock, generally more or less vertical or transverse to bedding, along which no appreciable movement has occurred.

*karst:* A type of topography that is formed over limestone, dolostone, or gypsum by dissolving or solution, and that is characterized by closed depressions or sinkholes, caves, and underground drainage.

*laminations:* The layering or bedding less than 1 cm in thickness in a sedimentary rock. The more or less distinct alternation of materials, which differ one from the other in grain size or composition.

*limestone:* A bedded sedimentary deposit consisting chiefly of calcium carbonate ($CaCO_3$) which yields lime when burned. It is the consolidated equivalent of limy mud, calcareous sand, or shell fragments.

*lithographic limestone:* An exceedingly fine–crystalline limestone used for lithography. Texture: a term used to denote grain size in calcareous sedimentary rocks. The grain size corresponds to that of clay, or less than 0.004 mm.

*marble:* A metamorphic rock composed essentially of calcite and/or dolomite.

*metabentonite:* Metamorphosed, altered or somewhat indurated bentonite characterized by minerals that are not normally found in bentonites. Does not possess the swelling and absorptive properties of bentonite.

*micrite:* A limestone with very fine–subcrystalline texture, such as a lithographic limestone.

*Mullusca:* A phylum of unsegmented, invertebrate animals that includes the gastropods, pelecypods, cephalopods, etc.

*mottled:* Irregularly marked with spots of different colours.

*mudcrack:* Desiccation crack, formed when a thin layer of mud dries, usually in a polygonal pattern.

*mudstone:* An indurated mud having the texture and composition of shale, but lacking its fine lamination or fissilty; a blocky or massive, fine–grained sedimentary rock in which the proporations of clay and silt are approximately equal.

*nodular:* Having the shape of or being composed of nodules. Said of certain ores or strata.

*nodule:* A small, irregular rounded knot, mass or lump of a mineral aggregate, normally having a warty or knobby surface and no internal structure, and usually exhibiting a contrasting composition from the enclosing sediment or rock matrix in which it is embedded. Most nodules appear to be secondary features.

*oolite:* 1) A spherical to ellipsoidal body (0.25–2.0 mm in diameter) which may or may not have a nucleus, and has concentric or radial structure or both. It is usually calcareous, but may be siliceous, hematitic, or of another composition. 2) A rock composed chiefly of ooliths.

*oolith:* The individual spherite of which an oolite (rock) is composed.

*ostracodes*: Any aquatic crustacean belonging to the subclass Ostracoda, characterized by a bivalve, generally calcified carapace with a hinge along the dorsal margin. Most are of microscopic size (0.4 – 1.5 mm long) although freshwater forms up to 5 mm long and marine forms up to 30 mm long are known.

*outcrop:* That part of a geologic formation or structure that appears at the surface of the earth.

*outlier:* An area or group of rocks surrounded by rocks of older age, e.g. an isolated hill or butte.

*parting:* A small joint or bedding plane in a layer of rock.

*Pelecypoda:* A division (class) of uncoiled, bivalve mollusks, with straight intestine and sometimes with a foot utilized in locomotion, also referred to as bivalves, commonly known as clams.

*pellet:* Small aggregation of sedimentary material, usually fecal in origin. In size, pellets are approximately 0.1–0.3 mm in diameter, and in few cases are several mm in length.

*pentamerid*: An articulate brachiopod assigned to the superfamily Pentameracea; characterized in general by large, strongly biconvex shell with a smooth, costellate, or costate exterior, and by spondylium in the pedicle valve.

*peridotite:* A coarse–grained, ultramafic rock consisting of olivine and pyroxene with accessory constituents.

*petroleum:* A naturally occurring, complex liquid hydrocarbon that may contain varying degrees of impurities (sulphur and nitrogen) which after distillation yields a range of combustible fuels, petrochemicals and lubricants.

*petroliferous:* Containing or yielding petroleum.

*platy:* 1) Said of a sedimentary particle whose length is more than three times its thickness. 2) Said of a sandstone or limestone that splits into laminae having thicknesses in the range of 2 to 10 mm.

*pyrite:* ($FeS_2$): Iron pyrites. "Fool's gold", Dimorphous with marcasite. Isometric, commonly in striated cubes or in pyritohedrons. Brass yellow. An important ore of sulfur, sometimes mined for the associated gold or copper.

*quartz:* A mineral, $SiO_2$. Hexagonal, trigonal–trapezohedral. A common constituent in clastic sediments.

*reed cast:* A vertical and cylindrical cast of sand presumably representing the filling of a mold left by a reed.

*reef:* A rock structure, either mound–like or layered, built by sedentary organisms such as corals, etc., and usually enclosed in a rock of differing lithologies.

*rip–up:* 1) Said of a sedimentary structure formed by shale clasts (usually of flat shape) that have been "ripped up" by currents from a semi–consolidated mud deposit and transported to a new depositional site. 2) Said of a clast in a rip–up structure.

*ripple mark:* An undulatory surface sculpture produced in non–coherent granular materials by the wind, by currents of water, or by agitation of water in wave action.

*Rugosa:* See horn coral.

*sandstone:* A cemented or otherwise compacted detrital sediment composed predominantly of quartz grains, the grades of the latter being those of sand.

*selenite:* A clear, transparent variety of gypsum, $CaSO_4$ $2H_20$.

*shale:* A laminated sediment in which the constituent particles are predominantly of the clay grade.

*shear zone:* A zone in which shearing has occurred on a large scale so that the rock is crushed and brecciated.

*siltstone:* A very fine–grained consolidated clastic rock composed predominantly of particles of silt grade.

*soft–sediment deformation:* Deformation of sediment laminae and bedding due to density irregularities in the sediment over– and underlying a unit.

*spicules:* 1) One of the numerous minute calcareous or siliceous bodies, having highly varied and often characteristic forms, occurring in and serving to stiffen and support the tissues of various invertebrates, and frequently found in marine–sediment samples and in Paleozoic and Cretaceous cherts. 2) The empty siliceous shell of a diatom.

*stromatolite:* Laminated, but otherwise structureless calcareous objects, commonly fossil calcareous algae.

*Stromatoporoidea:* Laminated, organic bodies made of calcium carbonate and probably by a hydrozoan.

*stylolite:* A term applied to parts of certain limestones which have a column–like development; the "columns" being generally at right angles or highly inclined to the bedding planes, having grooved, sutured or striated sides, and irregular cross–section. Due to pressure solution the solution contact usually possesses insoluble residues such as bitumen, clays, etc.

*subcrop:* Occurrence of strata on the undersurface of an inclusive stratigraphic unit that succeeds an important unconformity where overstepping is conspicuous. Area within which a formation occurs directly beneath an unconformity. In this report, usually the Paleozoic strata underlying Pleistocene deposits.

*sublithographic:* Said of a limestone whose texture approaches the exceedingly fine grain of lithographic limestone. Also, said of the texture of such a rock.

*sucrosic (saccharoidal):* A granular or crystalline texture resembling that of loaf sugar, or of the crystalline granular texture seen in some sandstones, evaporites, marbles, and dolostones.

*tabulate:* 1) Having tabulae, specifically said of a coral characterized by prominent tabulae.

*tentaculitids:* A marine invertebrate animal characterized by radial symmetry, a small conical shell with transverse rings of variable size and spacing, longitudinal striae, an embryonic chamber with bluntly pointed apex, and small pores in the shell wall.

*tetracoral:* A coral with four–fold symmetry.

*trace fossil:* A sedimentary structure consisting of a fossilized track, trail, burrow, tube, boring, or tunnel resulting from the life activities (other than growth) of an animal, such as a mark made by an invertebrate moving, creeping, feeding, hiding, browsing, running, or resting in soft sediment. It is preserved as a raised or depressed form in sedimentary rock.

*Trilobita:* Class of extinct arthropods with a dorsal skeleton consisting of a cephalon, thorax, and pygidium, and divided longitudinally into a central axis and two pleutral regions.

*vug/vuggy:* An empty cavity, often with a mineral lining of different composition from that of the surrounding rock.

*wavy bedding:* Bedding that is characterized by undulatory bounding surfaces.

# Appendix II
# Crystallinity Classification

| | |
|---|---|
| Coarse crystalline | over 5 mm |
| Medium crystalline | 1–5 mm |
| Fine crystalline | 0.2–1 mm |
| Very fine crystalline | under 0.2 mm; not detectable with the naked eye. |
| Subcrystalline | 0.05–0.2 mm; crystals detectable under 10X hand lens (= lithographic) |
| Microcrystalline | under 0.05 mm; crystals only detectable under microscopic examination (= lithographic). |

## GRAIN-SIZE CLASSIFICATION

| | |
|---|---|
| Boulder | Over 256 mm |
| Cobble | 64–256 mm |
| Pebble | 4–64 mm |
| Granule | 2–4 mm |
| Very coarse grained sand | 1–2 mm |
| Coarse grained sand | 0.5–1 mm |
| Medium grained sand | 0.25–0.5 mm |
| Fine grained sand | 0.125–0.25 mm |
| Very fine grained sand | 0.0625–0.125 mm |
| Silt | 0.004–0.0625 mm |
| Clay (mud) | Less than 0.004 mm |

## BEDDING CLASSIFICATION

| | |
|---|---|
| Massive bedded | over 100 cm |
| Thick bedded | 30–100 cm |
| Medium bedded | 10–30 cm |
| Thin bedded | 3–10 cm |
| Very thin bedded | 1–3 cm |
| Thick laminated | 0.3–1 cm |
| Thin laminated | less than 0.3 cm |

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Wynne-Edwards, H.R.

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1963: Geology, Brockville-Mallorytown Area, Ontario; Geological Survey of Canada, Map 7-1963, scale 1 inch to 1 mile, or 1:63,360.

# Appendix IV
# Inventory of All Known Paleozoic Limestone Quarries in Ontario

| Site No. | Quarry Name | Operator or Owner | MNR Lic | UTM | Coords | Township | Conc | Lot | MNR District | Active (*) | Thick-ness | Geological Formation(s) (Members) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A-01 | Zorra Qy | Lafarge Canada Inc. | YES | 17T | 507750E 4771500N | W Zorra | II, III, IV | 2–5, 2–4, 1–3 | Aylmer | Y | 48.8 m | Amherstburg, Lucas (Anderdon) |
| A-02 | Beachville Qy | Beachvilime Ltd. | YES | 17T | 512000E 4769000N | N Oxford | II, III | 17–18 | Aylmer | Y | 20.0 m | Lucas |
| A-03 | Beachville Qy | Beachvilime Ltd. | YES | 17T | 511100E 4767750N | N Oxford | II, III, IV, B.F. | 13–16, 15–18 | Aylmer | Y | 24.1 m | Lucas |
| A-04 | Stelco Qy –Beachville | Stelco Steel Inc. | YES | 17T | 510600E 4766450N | N Oxford | II, III, B.F. | 16–18, 5–17 & 12, 14, 15 | Aylmer | Y | 33.4 m | Lucas (sandy Anderdon) |
| A-06 | Strathroy Qy #1 | unknown | NO | 17T | 445400E 4758300N | Adelaide | II–III | 16 | Aylmer | N | 1.0 m | Widder |
| A-07 | Strathroy Qy #2 | unknown | NO | 17T | 445950E 4759400N | Adelaide | II | 17 | Aylmer | N | unknown | Widder |
| A-08 | Beachville Qy | Toronto Cement Corp. | NO | 17T | 514200E 4771200N | W Oxford | Broken Front | 6 | Aylmer | N | unknown | Lucas |
| A-09 | Rapson Qy | unknown | NO | 17T | 517800E 4773800N | W Oxford | Broken Front | Gore | Aylmer | N | 3.0 m | Lucas |
| A-10 | Wier Qy | unknown | NO | 17T | 518200E 4775800N | E Zorra | XI | 2 | Aylmer | N | 2.0 m | Bois Blanc |
| A-11 | Callan Estate Qy | unknown | NO | 17T | 524800E 4782700N | E Zorra | XVII | 9 | Aylmer | N | 2.0 m | Bertie |
| A-12 | Innerkip Qy | Innerkip Quarries, Ltd. | NO | 17T | 524600E 4782900N | E Zorra | XVII | 9 | Aylmer | N | 4.3 m | Bertie, Bois Blanc |
| A-13 | Innerkip Park Qy | unknown | NO | 17T | 524300E 4783300N | E Zorra | XVII | 10 | Aylmer | N | 3.5 m | Bois Blanc |
| BR-01 | Wport Qy | Griffin Brothers Constr. | YES | 18T | 387650E 4947350N | N Crosby | VII | 12 | Brockville | Y | 16.7 m | Gull River |
| BR-02 | Harlem Qy | Tackaberry & Sons | YES | 18T | 411200E 4946700N | Bastard | VI | 15 | Brockville | I | 3.7 m | March, Oxford |
| BR-03 | Newboyne (O'Grady) Qy | Tackaberry & Sons | YES | 18T | 414050E 4951050N | Bastard | V | 6 | Brockville | I | 3.8 m | March |
| BR-04 | O.Shirley & Sons Qy | O. Shirley & Sons | YES | 18T | 416450E 4968150N | S Elmsley | III | 9–10 | Brockville | I | 11.0 m | March |
| BR-05 | Newbliss (Willows) Qy | Tackaberry & Sons | YES | 18T | 420700E 4961800N | Kitley | III | 14–16 | Brockville | N | 8.0 m | Oxford |
| BR-06 | Leeds (Ronan) Qy | Tackaberry & Sons | YES | 18T | 422100E 4961700N | Kitley | III | 13 | Brockville | I | 10.4 m | Oxford |
| BR-07 | Frankville (Mercier) Qu. | Tackaberry & Sons | YES | 18T | 423650E 4952650N | Kitley | VIII | 19–20 | Brockville | I | 4.5 m | March |
| BR-08 | Athens (Lawson) Qy | Tackaberry & Sons | YES | 18T | 422300E 4944350N | Rr Yonge & Escott | X | 15 | Brockville | Y | 12.5 m | March |
| BR-09 | Jasper Qy | Tackaberry & Sons | YES | 18T | 425950E 4965800N | Wolford | I | 29–30 | Brockville | Y | 11.0 m | Oxford |
| BR-10 | Sherwood Springs Qy | William Clow | YES | 18T | 436800E 4929300N | Frnt Yonge | I | 2–3 | Brockville | Y | 4.5 m | March |
| BR-11 | Woods (Tincap) Qy | Tackaberry & Sons | YES | 18T | 438200E 4942000N | Elizabethtown | V | 20 | Brockville | Y | 10.0 m | Oxford |
| BR-12 | Brockville Qy | Permanent Concrete | YES | 18T | 447500E 4939800N | Elizabethtown | I | 3–5 | Brockville | Y | 20.1 m | March, Oxford |
| BR-13 | Brockville Qy | Dibblee Constr. | YES | 18T | 447350E 4940750N | Elizabethtown | I | 3–4 | Brockville | Y | 5.6 m | Oxford |
| BR-14 | Maitland (Wings) Qy | Tackaberry & Sons | YES | 18T | 450500E 4948250N | Augusta | III | 24–26 | Brockville | I | 6.0 m | Oxford |
| BR-15 | Kemptville Qy | Maple Grove (Kemptville) | YES | 18T | 452500E 4986000N | S Gower | VI | 10 | Brockville | I | 7.0 m | Oxford |
| BR-16 | Wport Qy # 2 | unknown | NO | 18T | 387800E 4946200N | N Crosby | VIII | 10 | Brockville | N | 1.0 m | Gull River |
| BR-17 | Freeland Qy | unknown | NO | 18T | 404500E 4950150N | Bastard | II | 21 | Brockville | N | 2.5 m | March |
| BR-18 | Lombardy Qy # 2 | unknown | NO | 18T | 413300E 4961600N | S Elmsley | II | 22 | Brockville | N | 3.0 m | Oxford |
| BR-19 | Lombardy Qy | unknown | NO | 18T | 416150E 4966400N | S Elmsley | III | 12 | Brockville | N | 2.5 m | Oxford |
| BR-20 | Shanes Qy | unknown | NO | 18T | 420200E 4965250N | S Elmsley | I | 8 | Brockville | N | 0.2 m | Oxford |
| BR-21 | Toledo Qy | unknown | NO | 18T | 421400E 4954850N | Kitley | VI | 21 | Brockville | N | 1.0 m | Oxford |
| BR-22 | Brandy Hill Qy | unknown | NO | 18T | 428050E 4958600N | Kitley | VII | 8 | Brockville | N | 1.8 m | March |
| BR-23 | Lehighs Corners Qy | unknown | NO | 18T | 425600E 4949900N | Kitley | X | 21 | Brockville | N | 2.0 m | Oxford |
| BR-24 | Eastons Corners Qy | unknown | NO | 18T | 429600E 4964900N | Wolford | II | 25 | Brockville | N | 0.5 m | Oxford |
| BR-25 | Oxford Mills Qy | Grenville Crushed Rock | NO | 18T | 441250E 4978250N | Oxford | III | 8–9 | Brockville | N | 6.0 m | Oxford |
| BR-26 | Main Qy | Tackaberry & Sons | YES | 18T | 419800E 4943800N | Rr Yonge & Escott | X | 21–22 | Brockville | I | 8.3 m | March |
| BR-27 | Wights Corners Qy | unknown | NO | 18T | 423100E 4943700N | Rr Yonge & Escott | IX | 14 | Brockville | N | 1.0 m | March |
| BR-28 | Athens Qy | Brundige Constr. Co. | NO | 18T | 423500E 4943000N | Rr Yonge & Escott | IX | 14 | Brockville | N | 0.0 m | March |
| BR-29 | Athens Qy | unknown | NO | 18T | 423100E 4941800N | Rr Yonge & Escott | IX | 16–17 | Brockville | N | 6.7 m | March |
| BR-30 | Hawkes Qy | unknown | NO | 18T | 427200E 4947700N | Rr Yonge & Escott | X | 1 | Brockville | N | 1.1 m | March |
| BR-31 | Brown's Bay Prov. Park | St. Lawrence Parks Commission | NO | 18T | 435500E 4927000N | Frnt Yonge | Broken Front | 7 | Brockville | N | 3.0 m | March |
| BR-32 | Jones Creek Qy | unknown | NO | 18T | 435950E 4928050N | Frnt Yonge | Broken Front | 5 | Brockville | N | 4.0 m | March |
| BR-33 | Forthton Qy | unknown | NO | 18T | 431400E 4943800N | Elizabethtown | VII | 33 | Brockville | N | 3.6 m | March |
| BR-34 | Bellamy Qy | unknown | NO | 18T | 435400E 4950300N | Elizabethtown | VIII | 17 | Brockville | N | 3.5 m | March |
| BR-35 | New Dublin Qy | Brundige Constr. Co. | NO | 18T | 436600E 4943900N | Elizabethtown | VI | 22 | Brockville | N | 7.0 m | Oxford |
| BR-36 | Fairfield E Qy | unknown | NO | 18T | 441600E 4947300N | Elizabethtown | V | 8 | Brockville | N | 0.8 m | March |
| BR-37 | Tincap Qy | Tackaberry & Sons | NO | 18T | 437200E 4941900N | Elizabethtown | V | 20 | Brockville | I | 10.1 m | Oxford |
| BR-38 | Tincap Qy | Dodge Constr. | NO | 18T | 440500E 4940650N | Elizabethtown | III | 17 | Brockville | N | 2.0 m | Oxford |

* Y = yes; N = no; I = intermittent

| Site No. | Quarry Name | Operator or Owner | MNR Lic | UTM | Coords | Township | Conc | Lot | MNR District | Active (*) | Thick-ness | Geological Formation(s) (Members) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BR-39 | Prescott Qy | unknown | NO | 18T | 457000E 4951300N | Augusta | I | 7 | Brockville | N | 1.8 m | March |
| BR-40 | Plums Qy | unknown | NO | 18T | 461300E 4952000N | Edwardsburgh | I | 33–34 | Brockville | N | 0.5 m | Oxford |
| BR-41 | Mills Qy | unknown | NO | 18T | 460500E 4959050N | Edwardsburgh | III | 26 | Brockville | N | 12.0 m | Oxford |
| BR-42 | Cardinal Qy # 2 | unknown | NO | 18T | 466500E 4960500N | Edwardsburgh | I | 11 | Brockville | N | 0.0 m | Oxford |
| BR-43 | Cardinal Qy # 1 | unknown | NO | 18T | 467900E 4958500N | Edwardsburgh | I | 11 | Brockville | N | 3.0 m | Oxford |
| CB-01 | Guelph Reformatory Qy | Guelph Reformatory | NO | 17T | 564500E 4822000N | Guelph | City of Guelph | – | Cambridge | N | 11.9 m | Amabel (Eramosa), Guelph |
| CB-02 | Guelph Qy | Guelph Dolime Ltd. | YES | 17T | 559800E 4818500N | Guelph | IV–V, Div G | 1–5 | Cambridge | Y | 19.0 m | Amabel (Eramosa), Guelph |
| CB-03 | Acton Qy | United Aggregates Ltd. | YES | 17T | 580200E 4830500N | Esquesing | III–IV | 21–24 | Cambridge | Y | 41.2 m | Reynales, Amabel |
| CB-04 | Milton (Dufferin) Qy | Dufferin Aggregates | YES | 17T | 584100E 4821300N | Esquesing & Nassagaweya | I & VII | 8–10 & 7–13 | Cambridge | Y | 30.8 m | Cabot Head, Reynales, Amabel |
| CB-05 | Halton (Milton) Qy | Halton Crushed Stone | YES | 17T | 583900E 4819000N | Nassagaweya | VI | 7–8 | Cambridge | Y | 23.5 m | Cabot Head, Reynales, Amabel |
| CB-06 | Milton Qy | Milton Limestone | YES | 17T | 587000E 4817450N | Nassagaweya | VII | 1–2 | Cambridge | Y | 24.1 m | Reynales, Amabel |
| CB-07 | Nelson (Mt. Nemo) Qy | Nelson Aggregate Co. | YES | 17T | 590500E 4807200N | Nelson | II–III | 1–2 | Cambridge | Y | 18.9 m | Reynales, Amabel |
| CB-08 | Old Nelson (Kerns Rd) Qu. | Nelson Crushed Stone | NO | 17T | 592500E 4800050N | Nelson | I S.D.S. | 24 | Cambridge | N | 15.7 m | Reynales, Irondequ., Rochr., Amabel |
| CB-09 | W Flamborough Qy | Flamboro Quarries Ltd. | YES | 17T | 579800E 4795500N | W Flamborough | IV | 5–6 | Cambridge | Y | 9.4 m | Lockport (Eramosa), Guelph |
| CB-10 | Clappisons Corners Qy | Armstrong Brothers | NO | 17T | 588600E 4798000N | E Flamborough | III | 12 | Cambridge | N | 9.7 m | Reynales, Irondeq., Roches., Lockpt. |
| CB-11 | Dundas (Steetley) Qy | Steetley Industries | YES | 17T | 582000E 4794000N | W Flamborough | II–IV | 7–11 | Cambridge | Y | 20.0 m | Lockport (Eramosa), Guelph |
| CB-12 | Stoney Creek Qy | Taro Aggregates | YES | 17T | 600000E 4783200N | Saltfleet | VI | new 25–26; old 27–28 | Cambridge | Y | 19.4 m | Lockport (Vinemount, Eramsoa) |
| CB-13 | Vinemount Qy | Waterford Sand & Gravel | YES | 17T | 608500E 4781100N | Saltfleet | V | 5 | Cambridge | Y | 19.5 m | Lockport(Goat Is., Vinemount,Eramosa) |
| CB-14 | Irvine Creek Qy | unknown | NO | 17T | 545400E 4836600N | Nichol | XI | 18–19 | Cambridge | N | unknown | Guelph |
| CB-15 | Elora Qy | Gypsum, Lime, & Alabast. | NO | 17T | 547125E 4837475N | Nichol | XII | 21 | Cambridge | N | 18.0 m | Guelph |
| CB-16 | Fergus Qy | James Gow | NO | 17T | 450100E 4838900N | Nichol | XV | 23 | Cambridge | N | 7.6 m | Guelph |
| CB-17 | O.H. Gow Qy | O.H. Gow | NO | 17T | 551500E 4839850N | W Garafraxa | I | 6 | Cambridge | N | 7.0 m | Guelph |
| CB-18 | Shands Qy | unknown | NO | 17T | 553100E 4842000N | W Garafraxa | III | 6 | Cambridge | N | unknown | Guelph |
| CB-19 | Erin Qy | W.J. Smith | NO | 17T | 571500E 4842400N | Erin | V | 15 | Cambridge | N | unknown | Guelph |
| CB-20 | Erin Qy | Ritchie Cut Stone Ltd. | NO | 17T | 572900E 4842900N | Erin | VI | 15 | Cambridge | N | 4.0 m | Guelph |
| CB-21 | Pearson (Erin) Qy | Wm. Pearson (1938) | NO | 17T | 576400E 4846900N | Erin | X | 13 | Cambridge | N | unknown | Amabel |
| CB-22 | Rockwood Qy # 2 | Rockwood Lime Co. Ltd. | NO | 17T | 569500E 4830950N | Eramosa | V | 7 | Cambridge | N | unknown | Amabel |
| CB-23 | Rockwood Qy | Rockwood Lime Co. Ltd. | NO | 17T | 569100E 4830300N | Eramosa | V | 6 | Cambridge | N | 12.1 m | Amabel |
| CB-24 | W Rockwood Qy | unknown | NO | 17T | 568100E 4829100N | Eramosa | IV | 6 | Cambridge | N | unknown | Amabel |
| CB-25 | Rockwood Qy # 3 | E. Harvey Ltd. | NO | 17T | 569400E 4828900N | Eramosa | IV | 4 | Cambridge | N | 3.5 m | Amabel |
| CB-26 | Silver Creek N Qy | unknown | NO | 17T | 582950E 4838250N | Esquesing | IX | 28 | Cambridge | N | unknown | Amabel |
| CB-27 | Glen Williams Qy | Industrial Sand & Gravel | NO | 17T | 583900E 4837750N | Esquesing | IX | 26 | Cambridge | N | 12.0 m | Amabel, Reynales |
| CB-28 | Georgetown Qy | Limehouse Crushed Stone | NO | 17T | 582200E 4836100N | Esquesing | VIII | 27 | Cambridge | N | 5.6 m | Amabel |
| CB-29 | Georgetown Qy | Armstrong Brothers | NO | 17T | 582800E 4833800N | Esquesing | VII | 24 | Cambridge | N | 7.4 m | Amabel |
| CB-30 | Limehouse Qy | Toronto Lime Co. | NO | 17T | 582600E 4832000N | Esquesing | VI | 22 | Cambridge | N | 3.0 m | Decew, Amabel |
| CB-31 | Speyside Qy | Standard Industries Ltd. | NO | 17T | 583500E 4824300N | Esquesing | II | 13 | Cambridge | N | 3.2 m | Amabel |
| CB-32 | Guelph Qy # 3 | unknown | NO | 17T | 561850E 4821700N | Guelph | City of Guelph | – | Cambridge | N | unknown | Guelph |
| CB-33 | Guelph Qy | Standard Aggregates | YES | 17T | 558800E 4815800N | Guelph | S.E. of Div B | 6 | Cambridge | N | 2.7 m | Guelph |
| CB-34 | Glenchristie Qy | Guelph Dolime Ltd. | YES | 17T | 557100E 4813600N | Puslinch | IV | 1–3 | Cambridge | N | 15.0 m | Guelph |
| CB-35 | Campbellville Qy | Fermar Paving Ltd. | NO | 17T | 581800E 4816950N | Nassagaweya | IV | 8 | Cambridge | N | 9.7 m | Amabel |
| CB-36 | Milton Qy | Gypsum, Lime, & Alabast. | NO | 17T | 586500E 4817500N | Nassagaweya | VI–VII | 4 | Cambridge | N | 15.5 m | Amabel |
| CB-37 | Kelso Qy | Gypsum, Lime, & Alabast. | NO | 17T | 585100E 4816600N | Nassagaweya | VI | 3–4 | Cambridge | N | 20.7 m | Reynales, Amabel |
| CB-38 | Rattlesnake Point Qy | unknown | NO | 17T | 587100E 4814600N | Nelson | VI | 14 | Cambridge | N | unknown | Amabel |
| CB-39 | Lowville Qy | Bay Crushed Stone–Lowville Quarries | NO | 17T | 591100E 4808400N | Nelson | IV | 3 | Cambridge | N | 17.7 m | Amabel |
| CB-40 | Nelson Qy | unknown | NO | 17T | 592100E 4804600N | Nelson | II | 16 | Cambridge | N | unknown | Amabel |
| CB-41 | Devil's Glen Qy | City of Cambridge | NO | 17T | 554300E 4802300N | N Dumfries | XII | W of Grand River | Cambridge | N | 10.4 m | Guelph |
| CB-42 | S Galt Qy | Chritie, Henderson, & Co. | NO | 17T | 555600E 4799450N | N Dumfries | X | 9 | Cambridge | N | 12.0 m | Guelph |
| CB-43 | Emerald Lake Qy | Gypsum, Lime, & Alabast. | NO | 17T | 570300E 4807000N | Puslinch | Puslinch Gore | 29 | Cambridge | N | 2.9 m | Guelph |
| CB-44 | Puslinch Qy | Steetley Industries | NO | 17T | 572500E 4807700N | Puslinch | Gore | 35 | Cambridge | N | 6.7 m | Guelph |
| CB-45 | Valens Qy | unknown | NO | 17T | 567300E 4802600N | Beverly | VIII or IX | 17 or 18 | Cambridge | N | 1.2 m | Guelph |

* Y = yes; N = no; I = intermittent

| Site No. | Quarry Name | Operator or Owner | MNR Lic | UTM | Coords | Township | Conc | Lot | MNR District | Active (*) | Thickness | Geological Formation(s) (Members) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CB-46 | Sheffield Qy | unknown | NO | 17T | 563200E 4797800N | Beverly | VII | 5 | Cambridge | N | 5.5 m | Guelph |
| CB-47 | Rockton Qy | George Collins | NO | 17T | 567650E 4794600N | Beverly | V | 14 | Cambridge | N | 2.2 m | Guelph |
| CB-48 | Rockton Qy | Township of Flamborough | YES | 17T | 567700E 4795700N | Beverly | IV | 18 | Cambridge | N | 3.9 m | Guelph |
| CB-49 | Troy Quarries | unknown | NO | 17T | 566800E 4790800N | Beverly | III | 8 & 9 | Cambridge | N | 2.0 m | Guelph |
| CB-50 | Freelton Qy | unknown | NO | 17T | 576600E 4804700N | W Flamborough | VIII | 3 | Cambridge | N | 8.0 m | Amabel |
| CB-51 | Hayesland Qy | unknown | NO | 17T | 579000E 4798000N | W Flamborough | V | 5-6 | Cambridge | N | 2.7 m | Guelph |
| CB-52 | Greensville Qy | unknown | NO | 17T | 490600E 4891900N | W Flamborough | II | 6 or 7 | Cambridge | N | 12.0 m | Lockport (Eramosa) |
| CB-53 | Dundas Qy | Canada Crushed Stone | NO | 17T | 584000E 4791600N | W Flamborough | I | 13-14 | Cambridge | N | 13.4 m | Lockport (Eramosa), Guelph |
| CB-54 | Ancaster Quarries | unknown | NO | 17T | 584000E 4787800N | Ancaster | II | 48 | Cambridge | N | 10.0 m | Lockport |
| CB-55 | Old Barton Twp. Qy | incl. Gallager Lime & Hamilton Lime | NO | 17T | 591000E 4785000N | Barton | VI-VII | 13-15 | Cambridge | N | unknown | Lockport |
| CB-56 | Rhymal Sta Qy # 1 | unknown | NO | 17T | 593950E 4783300N | Barton | VII | 5 | Cambridge | N | unknown | Lockport |
| CB-57 | Rhymal Sta Qy # 3 | unknown | NO | 17T | 593850E 4782900N | Barton | VII | 5 | Cambridge | N | unknown | Lockport |
| CB-58 | Rhymal Sta Qy # 4 | unknown | NO | 17T | 594700E 4787700N | Barton | VII | 5 | Cambridge | N | 4.0 m | Lockport |
| CB-59 | Hannon Qy | Wentworth County | NO | 17T | 595200E 4782050N | Barton | VIII | 1 | Cambridge | N | 6.7 m | Lockport (Eramosa) |
| CB-60 | Rhymal Sta Qy # 2 | unknown | NO | 17T | 594200E 4781900N | Glanford | I | 14 | Cambridge | N | unknown | Lockport |
| CB-61 | Rhymal Sta Qy | S.W. Miles | NO | 17T | 594300E 4781400N | Glanford | I | 14 | Cambridge | N | 9.5 m | Lockport (Eramosa), Guelph |
| CB-62 | Mount Hope Qy | unknown | NO | 17T | 588000E 4779000N | Glanford | IV | 5 | Cambridge | N | unknown | Guelph |
| CB-63 | Saltfleet Township Qy | Township of Saltfleet | NO | 17T | 599950E 4783700N | Saltfleet | V | 28 | Cambridge | N | unknown | Lockport |
| CB-64 | Tapleytown Qy | unknown | NO | 17T | 603500E 4782700N | Saltfleet | V | 17 | Cambridge | N | 5.0 m | Lockport |
| CB-65 | Tapleytown Qy | unknown | NO | 17T | 603100E 4781100N | Saltfleet | VII | 16 or 17 | Cambridge | N | 1.2 m | Lockport |
| CB-66 | Woodburn Qy | unknown | NO | 17T | 604250E 4778300N | Binbrook | I | 1, Block 1 | Cambridge | N | 2.0 m | Lockport (Eramosa) |
| CH-01 | MacGregor Qy | General Chemical Cnd. | YES | 17T | 333800E 4569500N | Anderdon | VI, VII | 8-10, & 9-10 | Chatham | Y | 32.0 m | Lucas (Anderdon) |
| CH-02 | Brunner Mond Qy | Brunner Mond Canada | NO | 17T | 327000E 4565000N | Anderdon | I | 6-8 | Chatham | N | 17.0 m | Lucas (Anderdon), Dundee |
| CH-02a | Allied Chemicals Qy | General Chemical Cnd. | NO | 17T | 327200E 4564200N | Anderdon | I | 2-3 | Chatham | N | 7.0 m | Lucas (Anderdon) |
| CH-03 | Amherstburg Qy | Amherst Quarries Ltd. | YES | 17T | 327500E 4662400N | Malden | II | 21-22 | Chatham | Y | 50.1 m | Amherstburg, Lucas |
| CH-04 | Pelee island Qy | 670026 Ont. Ltd. | YES | 17T | 363350E 4630675N | Pelee Island | R.P. 35 | 1-2 | Chatham | Y | 6.0 m | Dundee |
| CH-05 | Bastiansen Qy | John Bastiansen | YES | 17T | 426650E 4783150N | Bosanquet | Lake Range East | 41-42 | Chatham | I | 1.5 m | Widder |
| *CH-06* | *Thedford Qy* | *A. G. Cook Ltd.* | *NO* | *17T* | *427900E 4781800N* | *Bosanquet* | *VI* | *26* | *Chatham* | *I* | *2.5 m* | *Widder* |
| CH-07 | Thompson Qy | Dean Thompson | YES | 17T | 431000E 4781000N | Bosanquet | III | 24-25 | Chatham | I | 3.0 m | Widder |
| CH-08 | Sheridan Point Qy | Capt. John McCormick | NO | 17T | 360250E 4630500N | Pelee Island | Registered Plan 35 | 23 | Chatham | N | 3.0 m | Dundee |
| CH-09 | Scudder W Qy | Erie Sand & Gravel | YES | 17T | 361000E 4629700N | Pelee Island | R.P. 35 | 15 | Chatham | N | 2.5 m | Dundee |
| CH-10 | William McCormick Qy | William McCormick (in 1938) | NO | 17T | 360175E 4625450N | Pelee Island | Registered Plan 35 | 24 | Chatham | N | 5.3 m | Dundee |
| CH-11 | Pelee Island Twp. Qy | Township of Pelee Is. | NO | 17T | 360000E 4623900N | Pelee Island | Registered Plan 35 | 25 | Chatham | N | 3.0 m | Dundee |
| CH-12 | Pierce Qy | Burns Pierce | YES | 17T | 360600E 4623750N | Pelee Island | R.P. 35 | 27 | Chatham | I | 1.1 m | Dundee |
| CH-13 | Landfill Qy | unknown | NO | 17T | 360000E 4622700N | Pelee Island | R.P. 35 | 29 | Chatham | N | 1.0 m | Dundee |
| CO-01 | MacNammaras Qy | Nortario Limestone Ltd. | NO | 17T | 588450E 5288375N | Armstrong | VI | 6 | Cobalt | I | 3.3 m | Thornloe |
| CO-02 | Township of Harley Qy | Township of Harley | NO | 17T | 595525E 5278300N | Harley | VI | 7 | Cobalt | I | 4.5 m | Thornloe |
| CO-03 | Hanbury Qy | unknown | NO | 17T | 599750E 5273675N | Harley | III | 9 | Cobalt | N | 5.5 m | Thornloe |
| CO-04 | Dymond Clay Qy | Dymond Clay Products | NO | 17T | 600050E 5256675N | Bucke | IV | 9 | Cobalt | Y | 4.6 m | Farr |
| CO-05 | Farr Qy | unknown | NO | 17T | 601575E 5255550N | Bucke | III | 11 | Cobalt | N | 6.0 m | Farr |
| CO-06 | Earlton Airport Qy | unknown | NO | 17T | 584200E 5282950N | Armstrong | II | 10 | Cobalt | N | 6.0 m | Earlton |
| CO-07 | Middleton Qy | Roy Middleton | NO | 17T | 595700E 5278500N | Harley | V | 5 | Cobalt | N | 2.5 m | Thornloe |
| CO-08 | Dawson Point Qy | unknown | NO | 17T | 606700E 5261200N | Harris | I | 5 | Cobalt | N | 1.6 m | Thornloe |
| CO-09 | Sutton Bay Qy | unknown | NO | 17T | 604400E 5269900N | Harris | VII | – | Cobalt | N | 4.0 m | Evanturel Creek |
| CO-10 | Shipyards Qy | unknown | NO | 17T | 601400E 5258250N | Bucke | V | 6 | Cobalt | N | 14.0 m | Bucke, Farr |
| CP-01 | Arnprior Qy | Cavanagh Constr. | YES | 18T | 391000E 5026000N | Pakenham | IX | 26-27 | Carleton Pl. | Y | 4.0 m | Bobcaygeon |
| CP-02 | Kinburn Qy | Cavanagh Constr. | YES | 18T | 407300E 5022700N | Fitzroy | V | 4 | Carleton Pl. | Y | 9.3 m | Bobcaygeon |
| CP-03 | Almonte Qy | Robert C. Lyle (Burntland Aggregates) | YES | 18T | 408700E 5011500N | Ramsay | XII | 16-17 | Carleton Pl. | Y | 5.0 m | Bobcaygeon |
| CP-04 | W Carleton Qy | Cavanagh Constr. | YES | 18T | 411200E 5012550N | Huntley | XI | 15 | Carleton Pl. | Y | 16.5 m | Bobcaygeon |
| CP-05 | Carleton Pl. Qy | Duffy Road Oiling | YES | 18T | 410600E 5001650N | Ramsay | VIII | 2 | Carleton Pl. | I | 8.8 m | March, Oxford |
| CP-06 | Dunrobin Qy | George Kennedy | YES | 18T | 422800E 5031500N | Torbolton | V | 1 | Carleton Pl. | I | 5.0 m | Oxford, Rockcliffe |

* Y = yes; N = no; I = intermittent

| Site No. | Quarry Name | Operator or Owner | MNR Lic | UTM | Coords | Township | Conc | Lot | MNR District | Active (*) | Thick-ness | Geological Formation(s) (Members) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CP-07 | Franktown Qy | Cavanagh Constr. | YES | 18T | 419250E 4989450N | Beckwith | II | 16 | Carleton Pl. | I | 1.7 m | Oxford |
| CP-08 | Smith's Falls Qy | Warren Paving & Mat. | YES | 18T | 419800E 4974800N | Montague | V | 27–28 | Carleton Pl. | Y | 5.2 m | March |
| CP-09 | Spratt Qy | Spratt Sand & Gravel | YES | 18T | 424450E 5015500N | Huntley | II | 2–5 | Carleton Pl. | Y | 11.3 m | Bobcaygeon |
| CP-10 | Clarke Qy | Karson Kartage & Konstr. | YES | 18T | 424400E 5012400N | Huntley | IV | 1–2 | Carleton Pl. | Y | 20.0 m | Bobcaygeon |
| CP-11 | Cavanagh (Goulbourn) Qy | Cavanagh Constr. | YES | 18T | 423800E 5004650N | Goulbourn | VIII | 11 | Carleton Pl. | Y | 10.4 m | Gull River |
| CP-12 | Rosedale Qy | Tackaberry & Sons | YES | 18T | 425700E 4976400N | Montague | IV | 17 | Carleton Pl. | Y | 4.5 m | March |
| CP-13 | Kilmarnock Qy | Tackaberry & Sons | YES | 18T | 428000E 4972250N | Montague | I | 19 | Carleton Pl. | Y | 6.0 m | Oxford |
| CP-14 | Fallowfield Qy | R. W. Tomlinson | YES | 18T | 436050E 5014250N | Nepean | V | 24–25 | Carleton Pl. | Y | 10.9 m | Gull River, Bobcaygeon |
| CP-15 | Fallowfield Qy | Geo. Wimpey Can. Ltd. | YES | 18T | 436100E 5013700N | Nepean | V | 21–23 | Carleton Pl. | Y | 36.2 m | Gull River, Bobcaygeon |
| CP-16 | Fallowfield Qy | Warren Paving & Mat. | YES | 18T | 437500E 5013400N | Nepean | IV | 21 | Carleton Pl. | Y | 18.7 m | Gull River, Bobcaygeon |
| CP-17 | S Gloucester Qy | United Aggregates Ltd. | YES | 18T | 455150E 5016500N | Gloucester | V | 24–25 | Carleton Pl. | Y | 27.3 m | March, Oxford |
| CP-18 | S Gloucester Qy | Warren Paving & Mat. | YES | 18T | 455600E 5016600N | Gloucester | V | 25 | Carleton Pl. | Y | 12.2 m | March, Oxford |
| CP-19 | S Gloucester Qy | Beaver Asphalt | YES | 18T | 456200E 5016050N | Gloucester | V | 26–27 | Carleton Pl. | Y | 13.5 m | Oxford |
| CP-20 | Hawthorne Road Qy | Permanent Concrete | YES | 18T | 457050E 5016250N | Gloucester | VI | 28 | Carleton Pl. | Y | 12.3 m | March, Oxford |
| CP-21 | Greely Qy | Cornwall Sand & Gravel | YES | 18T | 459800E 5010000N | Osgoode | VI | 14 | Carleton Pl. | Y | 8.0 m | Oxford |
| CP-22 | Francon Qy | Francon–Division of Canfarge | YES | 18T | 455600E 5032600N | Gloucester | II | 12–14 | Carleton Pl. | Y | 135 m | Gull River, Bobcaygeon |
| CP-23 | LeBlanc Qy | Permanent Concrete | YES | 18T | 469750E 5031500N | Cumberland | VI | 7–9 | Carleton Pl. | Y | 21.0 m | Lindsay |
| CP-24 | Sarsfield Qy | Bertrand et Frere Constr. | YES | 18T | 474300E 5031100N | Cumberland | III | 12 | Carleton Pl. | Y | 13.0 m | Lindsay |
| CP-25 | Arnprior Qy | unknown | NO | 18T | 395100E 5026300N | Pakenham | XII | 22–23 | Carleton Pl. | N | 2.0 m | Gull River |
| CP-26 | Pakenham Qy | unknown | NO | 18T | 399450E 5020700N | Pakenham | XI | 11 | Carleton Pl. | N | 7.6 m | Bobcaygeon |
| CP-27 | County of Lanark Qy | unknown | NO | 18T | 400000E 5021000N | Pakenham | XII | 11 | Carleton Pl. | N | 1.0 m | Bobcaygeon |
| CP-28 | Pakenham Qy | unknown | NO | 18T | 400100E 5020500N | Pakenham | XII | 9–10 | Carleton Pl. | N | 2.0 m | Bobcaygeon |
| CP-29 | Marathon Qy | unknown | NO | 18T | 410600E 5021900N | Fitzroy | VI | 1 | Carleton Pl. | N | 2.0 m | Bobcaygeon |
| CP-30 | Hodgins Qy | unknown | NO | 18T | 412300E 5025200N | Fitzroy | IX | 3 | Carleton Pl. | N | 2.0 m | Gull River |
| CP-31 | Snedden Qy | unknown | NO | 18T | 403400E 5013950N | Ramsay | X | 24 | Carleton Pl. | N | 3.0 m | Gull River |
| CP-32 | McGill Qy | B. McGill | YES | 18T | 406000E 5009500N | Ramsay | Town of Almonte | 3–4 | Carleton Pl. | N | 0.5 m | Bobcaygeon |
| CP-33 | Galbraith Qy | unknown | NO | 18T | 407100E 5000300N | Ramsay | VI | 5 | Carleton Pl. | N | 3.0 m | March |
| CP-34 | Carp Qy | Bertrand Concrete Prod. | YES | 18T | 412000E 5018000N | Huntley | VIII | 21 | Carleton Pl. | I | 3.5 m | Bobcaygeon |
| CP-35 | Stittsville Qy | unknown | NO | 18T | 422000E 5013000N | Huntley | V | 4 | Carleton Pl. | N | 4.0 m | Bobcaygeon |
| CP-36 | MacMillan Qy | Allan MacMillan | NO | 18T | 416750E 5005500N | Huntley | II | 1 | Carleton Pl. | I | 1.0 m | Gull River |
| CP-37 | Harwood Plains Qy | unknown | NO | 18T | 422800E 5024950N | March | II | 18 | Carleton Pl. | N | 2.7 m | March |
| CP-38 | Malwood Qy | unknown | NO | 18T | 424300E 5029650N | March | V | 22 | Carleton Pl. | N | 3.4 m | Rockcliffe (St. Martin) |
| CP-39 | Strathearn Qy | unknown | NO | 18T | 428600E 5022950N | March | V | 9 | Carleton Pl. | N | 1.4 m | Oxford |
| CP-40 | Drummond Centre Qy #3 | unknown | NO | 18T | 400700E 4982000N | Drummond | VII | 11 | Carleton Pl. | N | 1.0 m | March |
| CP-41 | Drummond Centre Qy #2 | unknown | NO | 18T | 402950E 4978750N | Drummond | IV | 10 | Carleton Pl. | N | 3.0 m | March |
| CP-42 | Drummond Centre Qy #1 | unknown | NO | 18T | 403400E 4078900N | Drummond | IV | 11 | Carleton Pl. | N | 2.0 m | March |
| CP-43 | Barrie Qy | unknown | NO | 18T | 403200E 4977900N | Drummond | III | 10 | Carleton Pl. | N | 3.0 m | March |
| CP-44 | Tay Qy | unknown | NO | 18T | 406950E 4972900N | N Elmsley | IX | 18 | Carleton Pl. | N | 4.0 m | March |
| CP-45 | Highway 43 Qy | unknown | NO | 18T | 416500E 4973400N | N Elmsley | VI | 3 | Carleton Pl. | N | 3.0 m | March |
| CP-46 | Carleton Pl. Qy | unknown | NO | 18T | 411000E 4997400N | Beckwith | XI | 14 | Carleton Pl. | N | 1.0 m | March |
| CP-47 | Beckwith Qy | unknown | NO | 18T | 413700E 4992000N | Ramsay | VI | 11 | Carleton Pl. | N | 3.5 m | March |
| CP-48 | Smith's Falls Qy | Ontario Building Mat. | NO | 18T | 419200E 4974100N | Montague | V | 29 | Carleton Pl. | N | [illegible].5 m | March |
| CP-49 | Highway 7 Qy | unknown | NO | 18T | 419000E 5006700N | Goulbourn | XII | 7 | Carleton Pl. | N | 4.0 m | Gull River |
| CP-50 | Stittsville Qy | Warren Paving & Mat. | YES | 18T | 422650E 5008400N | Goulbourn | XI | 13–14 | Carleton Pl. | I | 2.7 m | Gull River |
| CP-51 | Ashton Qy | unknown | NO | 18T | 421800E 5003500N | Goulbourn | IX | 7 | Carleton Pl. | N | 0.5 m | Gull River |
| CP-52 | Mansfield Qy | unknown | NO | 18T | 424800E 5005900N | Goulbourn | IX | 13 | Carleton Pl. | N | 1.2 m | Gull River |
| CP-53 | Stapledon Qy | unknown | NO | 18T | 430300E 5001200N | Goulbourn | III | 15 | Carleton Pl. | N | 0.5 m | Gull River |
| CP-54 | Dwyer Hill Qy | unknown | NO | 18T | 428000E 4994700N | Goulbourn | I | 6 | Carleton Pl. | N | 2.0 m | March |
| CP-55 | Shirleys Bay Qy | unknown | NO | 18T | 430000E 5023000N | Nepean | A on Ottawa River | 3 | Carleton Pl. | N | 0.8 m | Oxford |
| CP-56 | Bruce Farm Qy | unknown | NO | 18T | 436700E 5020500N | Nepean | II on Ottawa River | 16 | Carleton Pl. | N | 4.5 m | Oxford |
| CP-57 | Fallowfield Qy | unknown | NO | 18T | 437000E 5014700N | Nepean | IV | 24 | Carleton Pl. | N | 1.0 m | March |
| CP-58 | Clyde Avenue Qy | Frazer Duntile Ltd. | NO | 18T | 441500E 5024300N | Gloucester | City of Ottawa | – | Carleton Pl. | N | 9.8 m | Gull River, Bobcaygeon |
| CP-59 | Brule Qy | unknown | NO | 18T | 445700E 5024500N | Gloucester | City of Ottawa | – | Carleton Pl. | N | 4.0 m | Bobcaygeon |
| CP-60 | McCarthy Road Qy | Dibblee Constr. Co. | NO | 18T | 447600E 5022100N | Gloucester | III | 3–4 | Carleton Pl. | N | 20.8 m | Gull River, Bobcaygeon |
| CP-61 | Orleans Qy | Frazer Duntile Ltd. | NO | 18T | 458750E 5036400N | Gloucester | I | 3 | Carleton Pl. | N | 8.8 m | Bobcaygeon |

* Y = yes; N = no; I = intermittent

| Site No. | Quarry Name | Operator or Owner | MNR Lic | UTM | Coords | Township | Conc | Lot | MNR District | Active (*) | Thick-ness | Geological Formation(s) (Members) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CP-62 | Queenswood Village Qy | unknown | NO | 18T | 460300E 5036500N | Cumberland | I from Ottawa River | 36 | Carleton Pl. | N | 8.5 m | Bobcaygeon |
| CP-63 | Cumberland Qy | unknown | NO | 18T | 464000E 5039700N | Cumberland | I from Ottawa River | 25 | Carleton Pl. | N | 20.0 m | Oxford, Rockcliffe |
| CP-64 | Navan Qy | unknown | NO | 18T | 465000E 5031500N | Cumberland | IX | 8 | Carleton Pl. | N | 1.7 m | Lindsay |
| CP-65 | Herbert Corners Qy | unknown | NO | 18T | 454200E 5009800N | Osgoode | IV | 7 | Carleton Pl. | N | 0.0 m | Oxford |
| CP-66 | Metcalfe Qy | unknown | NO | 18T | 460500E 5010300N | Osgoode | VII | 15 | Carleton Pl. | N | 2.5 m | Oxford |
| CP-67 | Tomlinson (Metcalfe) Qu. | unknown | NO | 18T | 467000E 5011800N | Osgoode | X | 20 | Carleton Pl. | N | 2.9 m | Oxford |
| CP-68 | Marrionville Qy | unknown | NO | 18T | 471800E 5002950N | Osgoode | XI | 44 | Carleton Pl. | N | 0.7 m | Oxford |
| CW-01 | Forbes Qy | Barry Forbes | YES | 18T | 460400E 4989450N | Mountain | VIII | 8 | Cornwall | Y | 8.0 m | Oxford |
| CW-02 | Iroquois Qy | Fetterley/Cornwall Gravel | YES | 18T | 473200E 4963400N | Matilda | Range I | 30–31 | Cornwall | Y | 27.6 m | Oxford |
| CW-03 | Williamsburgh Qy | Cruickshank Constr. | YES | 18T | 478700E 4983150N | Williamsburgh | VII | 31 | Cornwall | Y | 14.2 m | Gull River |
| CW-04 | St. Albert Sta Qy | A. L. Blair Constr. | YES | 18T | 483900E 5008850N | Finch | XII | 7–8 | Cornwall | Y | 14.9 m | Bobcaygeon |
| CW-05 | Embrum Qy | A. L. Blair Constr. | YES | 18T | 479100E 5012600N | Russell | VIII | 6–7 | Cornwall | Y | 12.0 m | Bobcaygeon |
| CW-06 | Limoges Qy | Dibblee Constr. | YES | 18T | 481300E 5015800N | Russell | X | 9 | Cornwall | N | 6.0 m | Lindsay |
| CW-07 | Canaan Qy | Clarence Township | YES | 18T | 477550E 5033200N | Clarence | XI | 11 | Cornwall | Y | 17.0 m | Lindsay |
| CW-08 | Rockland (Stewart) Qy | unknown | NO | 18T | 477000E 5041500N | Clarence | IX | B & C | Cornwall | N | 29.8 m | Bobcaygeon, Gull River |
| CW-09 | Richier Qy | Cornwall Gravel | YES | 18T | 494875E 5012780N | Cambridge | X | 10 | Cornwall | Y | 12.7 m | Lindsay |
| CW-10 | Finch Qy | A. L. Blair Constr. | YES | 18T | 492500E 4997350N | Finch | II | 11 | Cornwall | Y | 4.5 m | Verulam |
| CW-11 | Plumadore Qy | A. L. Blair Constr. | YES | 18T | 495600E 4986750N | Osnabruck | V | 27 | Cornwall | I | 3.0 m | Verulam |
| CW-11a | Osnabruck Centre Qy | Township of Osnabruck | YES | 18T | 495400E 4986800N | Osnabruck | V | 26 | Cornwall | I | 4.5 m | Verulam |
| CW-12 | Cornwall Qy | Permanent Concrete | YES | 18T | 512700E 4987800N | Cornwall | IV | 25–29 | Cornwall | Y | 19.1 m | Gull River, Bobcaygeon |
| CW-13 | Cornwall Qy | Warren Paving & Mat. | YES | 18T | 513450E 4988050N | Cornwall | IV | 23 | Cornwall | Y | 9.7 m | Gull River, Bobcaygeon |
| CW-14 | MacLeod Qy | Cornwall Gravel Co. | YES | 18T | 521800E 4992800N | Cornwall | IV | 3–5 | Cornwall | Y | 33.4 m | Gull River, Bobcaygeon |
| CW-15 | Apple Hill Qy | A. L. Blair Constr. | YES | 18T | 517760E 5002400N | Charlottenburgh | IX | 11–14 | Cornwall | Y | 4.5 m | Lindsay |
| CW-16 | Gravel Hill Qy | A. L. Blair Constr.. | YES | 18T | 509150E 5007150N | Roxborough | IV | 9 | Cornwall | Y | 4.2 m | Lindsay |
| CW-17 | Moose Creek Qy | A. L. Blair Constr. | YES | 18T | 501700E 5008600N | Roxborough | VI | 24 | Cornwall | Y | 5.6 m | Lindsay |
| CW-18 | Tayside Qy | A. L. Blair Constr. | YES | 18T | 502500E 5018000N | Roxborough | X | 10 | Cornwall | Y | 6.6 m | Lindsay |
| CW-19 | St. Isodore Qy | Bertrand et Frere Constr. | YES | 18T | 508000E 5022150N | S Plantagenet | XX | 7 | Cornwall | Y | 10.9 m | Lindsay |
| CW-20 | Alfred Qy | Raymond Tierney | YES | 18T | 507000E 5047580N | Alfred | III | 28 | Cornwall | I | 3.0 m | Rockcliffe |
| CW-21 | L'Orignal Qy | Bertrand et Frere Constr. | YES | 18T | 518550E 5049050N | Longueuil | -- | 213–215 | Cornwall | Y | 15.2 m | Bobcaygeon |
| CW-22 | Ross Qy | Sintra Inc. | YES | 18T | 536850E 5046350N | E Hawkesbury | I | 28 | Cornwall | Y | 9.5 m | Rockcliffe |
| CW-23 | McAlpine Qy | Cliftondale Aggregates | YES | 18T | 522900E 5042800N | Caledonia | I | 1–2 | Cornwall | Y | 10.2 m | Bobcaygeon |
| CW-24 | Skye Qy | Sintra Inc. | YES | 18T | 514180E 5028675N | Caledonia | VIII | 12 | Cornwall | Y | 9.3 m | Bobcaygeon |
| CW-25 | Gauthier Qy | Cruickshank Constr. | YES | 18T | 513350E 5026250N | Caledonia | IX | 12 | Cornwall | I | 5.5 m | Bobcaygeon |
| CW-26 | Fiskes Corners Qy | A. L. Blair Constr. | YES | 18T | 519750E 5023350N | Kenyon | VIII | 12 | Cornwall | Y | 7.0 m | Bobcaygeon |
| CW-27 | Green Valley | Cruickshank Constr. | YES | 18T | 536450E 5010300N | Lancaster | VI | 29 | Cornwall | Y | 13.8 m | Bobcaygeon, Gull River |
| CW-30 | Rockland Qy | unknown | NO | 18T | 377250E 5044400N | Clarence | Village of Rockland | -- | Cornwall | N | 8.0 m | Oxford |
| CW-31 | Orient Qy | unknown | NO | 18T | 486000E 5045300N | Clarence | on Ottawa River | 5 | Cornwall | N | 2.1 m | Bobcaygeon |
| CW-32 | Beauchamp Qy | unknown | NO | 18T | 483000E 5039800N | Clarence | V | 4 | Cornwall | N | 0.5 m | Lindsay |
| CW-33 | St. Pascal Qy | unknown | NO | 18T | 484650E 5037900N | Clarence | V | 8 | Cornwall | N | 2.0 m | Lindsay |
| CW-34 | Bourget Qy | unknown | NO | 18T | 484000E 5029850N | Clarence | VII | 20 | Cornwall | N | 1.0 m | Lindsay |
| CW-35 | Rollway Qy | unknown | NO | 18T | 494000E 5043600N | N Plantagenet | II | 24 | Cornwall | N | 8.0 m | Lindsay |
| CW-36 | S Nation Prov. Qy | unknown | NO | 18T | 496300E 5044600N | N Plantagenet | II | 19 | Cornwall | N | 1.0 m | Lindsay |
| CW-37 | Centrefield Qy | unknown | NO | 18T | 498500E 5043200N | N Plantagenet | III | 10 | Cornwall | N | 5.0 m | Lindsay |
| CW-38 | Treadwell Qy | unknown | NO | 18T | 499800E 5047300N | N Plantagenet | I | 7 | Cornwall | N | 2.9 m | Lindsay |
| CW-39 | Alfred Qy # 1 | unknown | NO | 18T | 505000E 5043200N | Alfred | VI | 3 | Cornwall | N | 0 m | Lindsay |
| CW-40 | Lett Qy | unknown | NO | 18T | 506700E 5046300N | Alfred | IV | 6 | Cornwall | N | unknown | Bobcaygeon |
| CW-41 | Alfred Qy # 2 | unknown | NO | 18T | 509850E 5044000N | Alfred | VI | 9 | Cornwall | N | 3.0 m | Lindsay |
| CW-42 | Alfred Qy # 3 | unknown | NO | 18T | 509700E 5046950N | Alfred | IV | 11 | Cornwall | N | 7.7 m | Bobcaygeon |
| CW-43 | Alfred Qy # 4 | unknown | NO | 18T | 512200E 5047300N | Alfred | V | 15 | Cornwall | N | 1.0 m | Bobcaygeon |
| CW-44 | Alfred Qy # 5 | unknown | NO | 18T | 512600E 5047100N | Alfred | V | 15 | Cornwall | N | 0 m | Bobcaygeon |
| CW-45 | Howes Qy | unknown | NO | 18T | 525300E 5051150N | Longueuil | -- | -- | Cornwall | N | 2.0 m | Bobcaygeon |
| CW-47 | Dunvegan Qy | unknown | NO | 18T | 513500E 5024500N | Kenyon | IX | 24 | Cornwall | N | 0.5 m | Lindsay |
| CW-48 | Menard Qy | unknown | NO | 18T | 478200E 5012300N | Russell | VII | 7 | Cornwall | N | 6.3 m | Gull River |
| CW-49 | Embrun Qy | unknown | NO | 18T | 479250E 5013000N | Russell | VIII | 7 | Cornwall | N | 4.0 m | Bobcaygeon |

* Y = yes; N = no; I = intermittent

| Site No. | Quarry Name | Operator or Owner | MNR Lic | UTM | Coords | Township | Conc | Lot | MNR District | Active (*) | Thick-ness | Geological Formation(s) (Members) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CW-50 | Limoges Qy | unknown | NO | 18T | 481850E 5016600N | Cambridge | V | 30 | Cornwall | N | 3.9 m | Lindsay |
| CW-51 | Crysler Qy | unknown | NO | 18T | 487150E 5009750N | Cambridge | X | 25 | Cornwall | N | 1.0 m | Verulam |
| CW-52 | Patterson Qy | Edward Robinson | NO | 18T | 468000E 4991000N | Mountain | VII | 20 | Cornwall | N | 2.9 m | Oxford |
| CW-53 | S Mountain Qy | Cruickshank Constr. | YES | 18T | 466550E 4982350N | Mountain | II | 11 | Cornwall | Y | 0.3 m | Oxford |
| CW-54 | S Mountain Qy | Forbes Building Mat. | YES | 18T | 468200E 4981700N | Mountain | I | 13 | Cornwall | Y | 1.5 m | Rockcliffe |
| CW-55 | Baker Qy | unknown | NO | 18T | 472500E 4991800N | Winchester | VI | 3 | Cornwall | N | 0.0 m | Gull River |
| CW-56 | Chesterville Qy | Cornwall Gravel. | YES | 18T | 483350E 4991100N | Winchester | I | 17-18 | Cornwall | I | 1.4 m | Gull River |
| CW-57 | Crysler Qy | unknown | NO | 18T | 489600E 5004600N | Finch | VIII | 13 | Cornwall | N | 1.7 m | Verulam |
| CW-58 | Finch Qy | unknown | NO | 18T | 491000E 4997500N | Finch | III | 9 | Cornwall | N | 1.0 m | Verulam |
| CW-59 | Finch Qy | A. L. Blair Constr. | YES | 18T | 498100E 5001800N | Finch | III | 23 | Cornwall | I | 1.0 m | Lindsay |
| CW-60 | Iroquois Qy | unknown | NO | 18T | 473000E 4963700N | Matilda | Range I | 31 | Cornwall | N | 1.0 m | Oxford |
| CW-61 | Fisher Qy | unknown | NO | 18T | 473750E 4963650N | Matilda | Range I | 28-29 | Cornwall | N | 2.0 m | Oxford |
| CW-62 | Williamsburgh Qy | Warren Paving & Mat. | YES | 18T | 478100E 4982850N | Williamsburgh | VII | 33 | Cornwall | I | 4.3 m | Gull River |
| CW-63 | Whittaker Qy | unknown | NO | 18T | 477950E 4980150N | Williamsburgh | VI | 35 | Cornwall | N | 1.0 m | Gull River |
| CW-64 | Dunbar Qy | unknown | NO | 18T | 482000E 4987950N | Williamsburgh | VIII | 18 | Cornwall | N | 1.0 m | Gull River |
| CW-65 | Boucks Hill Qy | Cruickshank Constr. | NO | 18T | 483900E 4981950N | Williamsburgh | V | 21 | Cornwall | N | 0.9 m | Gull River |
| CW-66 | Durham Wells Qy | Dibblee Constr. Co. Ltd. | NO | 18T | 490900E 4983800N | Williamsburgh | IV | 4 | Cornwall | N | 0.5 m | Gull River |
| CW-67 | Cornwall Centre Qy | Ontario Hydro | NO | 18T | 514300E 4988700N | Cornwall | IV | 20 | Cornwall | N | 18.3 m | Gull River, Bobcaygeon |
| CW-68 | Apple Hill Qy | Roads Resurfacing Co. | NO | 18T | 519400E 5002750N | Charlottenburgh | IX | 11 | Cornwall | N | 4.7 m | Lindsay |
| CW-69 | McGillivary's Bridge Qu. | unknown | NO | 18T | 526300E 4998150N | Charlottenburgh | S of Raisin River | 34 | Cornwall | N | 0.9 m | Verulam |
| CW-70 | Summerstown Sta Qu. | unknown | NO | 18T | 533500E 4992300N | Charlottenburgh | II | 11 | Cornwall | N | 1.0 m | Bobcaygeon |
| ES-01 | Manitoulin Qy | Standard Aggregates | NO | 17T | 327600E 5086400N | Dawson | IX | 45 | Espanola | Y | 25.0 m | Fossil Hill, Amabel |
| ES-02 | Foxey Qy | Hercules Ornamental St. | NO | 17T | 382500E 5079850N | Gordon | V | 17 | Espanola | Y | 0.5 m | Manitoulin |
| ES-03 | Cup & Saucer Qy | Harnden & King | NO | 17T | 414330E 5078750N | Bidwell | VIII | 29 | Espanola | Y | 11.0 m | St. Edmund, Fossil Hill |
| ES-04 | Cockburn Island Qy | unknown | NO | 17T | 321100E 5091200N | Cockburn Island | XI | 8 | Espanola | N | 6.7 m | St. Edmund, Fossil Hill |
| ES-05 | Kagawong W Qy | unknown | NO | 17T | 400200E 5085250N | Allan | IX | 4 | Espanola | N | 10.2 m | Georgian Bay, Manitoulin |
| ES-06 | Qy Bay Qy | unknown | NO | 17T | 338750E 5080800N | Dawson | IV | 17 | Espanola | N | 2.0 m | Amabel |
| ES-07 | Leason Qy | unknown | NO | 17T | 423500E 5050000N | Tehkummah | VIII | 12 | Espanola | N | 10.0 m | Amabel |
| H-01 | Duntroon Qy | McKean Quarries Ltd. | YES | 17T | 560250E 4914520N | Nottawasaga | XII | 24 | Huronia | Y | 12.0 m | Amabel |
| H-02 | Duntroon Qy | Angelstone Ltd. | NO | 17T | 561450E 4915200N | Nottawasaga | XI | 24 | Huronia | N | 10.3 m | Queenston, Whirlpool, Manitoulin |
| H-03 | Coldwater (Waubaushene) Qy | Allan G. Cook Ltd. | YES | 17T | 606300E 4958200N | Tay | XIV | 8-11 | Huronia | Y | 11.0 m | Gull River |
| H-04 | Medonte (Coldwater) Qy. | Ministry of Transportation | NO | 17T | 609600E 4950700N | Medonte | XIII | 19-20 | Huronia | N | 14.2 m | Gull River, Bobcaygeon |
| H-05 | Uhthoff Qy | Nelson Aggregate Co. | YES | 17T | 619200E 4949500N | Orillia | III-V N Div. | 7-10 | Huronia | Y | 24.6 m | Gull River, Bobcaygeon |
| H-06 | Woods (Longford) Qy | Fowler Constr. Co. Ltd. | YES | 17T | 631800E 4950400N | Rama | BF | 26-29 | Huronia | Y | 5.4 m | Gull River |
| H-07 | Rama Township Qy | Rama Township | NO | 17T | 637400E 4950300N | Rama | E | 3 | Huronia | I | 5.0 m | Shadow Lake, Gull River |
| H-08 | Gamebridge Qy | Mara Limestone Aggr. | YES | 17T | 646175E 4928900N | Mara | A | 11-12 | Huronia | Y | 10.5 m | Verulam |
| H-09 | Brechin Qy | Standard Aggregates | YES | 17T | 646500E 4932000N | Mara | I-II | 7-10 | Huronia | Y | 24.8 m | Bobcaygeon, Verulam |
| H-10 | Speiran Qy | Carson S. Speiran | YES | 17T | 638800E 4948050N | Rama | B | 3-4 | Huronia | Y | <1.0 m | Gull River |
| H-11 | Pigeon Point Qy | Cramp Steel Mills Co. | NO | 17T | 558500E 4929000N | Nottawasaga | XI | 46 | Huronia | N | 0.0 m | Lindsay |
| H-12 | Town of Collingwood Qu. | Town of Collingwood | NO | 17T | 560400E 4928700N | Nottawasaga | X | 46 | Huronia | N | unknown | Lindsay |
| H-13 | Merchants Qy | Law Constr. Co. | NO | 17T | 563350E 4927850N | Nottawasaga | Town of Collingwood | - | Huronia | N | 0.0 m | Lindsay |
| H-14 | Batteaux River Qy | unknown | NO | 17T | 565800E 4926550N | Nottawasaga | VI | 40-41 | Huronia | N | 4.0 m | Lindsay |
| H-15 | Corbetton Qy | unknown | NO | 17T | 551550E 4889900N | Melancthon | I | 244 | Huronia | N | unknown | Guelph |
| H-16 | Shelburne Qy | Ritchie Cut Stone Ltd. | NO | 17T | 565500E 4880975N | Amaranth | I | 32 | Huronia | N | 5.0 m | Amabel |
| H-17 | Waldemar Qy | unknown | NO | 17T | 557550E 4859600N | Amaranth | IX | 2 | Huronia | N | ?2.0 m | Guelph |
| H-18 | Purple Hill Qy | unknown | NO | 17T | 574900E 4864100N | Mono | I EHS | 1 | Huronia | N | unknown | Amabel |
| H-19 | Port McNicoll Qy | Canada Iron Furnace Co. | NO | 17T | 593150E 4957300N | Tay | V | 19-20 | Huronia | N | 9.9 m | Gull River |
| H-20 | Medonte Qy | unknown | NO | 17T | 610050E 4951850N | Medonte | XIV | 20 | Huronia | N | 4.0 m | Gull River |
| H-21 | Foxmead Qy | unknown | NO | 17T | 614800E 4960850N | Orillia | II N Div. | 15-16 | Huronia | N | 1.0 m | Gull River |
| H-22 | Hampshire Mills Qy | unknown | NO | 17T | 621600E 4952000N | Orillia | VII | 11 | Huronia | N | 7.6 m | Gull River, Bobcaygeon |
| H-23 | Grass Lake Qy | unknown | NO | 17T | 626050E 4958100N | Orillia | XII | 17 | Huronia | N | unknown | Gull River |
| H-24 | Lake St. George Qy | unknown | NO | 17T | 629050E 4954600N | Orillia | XII | 9 | Huronia | N | 2.5 m | Gull River |
| H-25 | Lake St. George S Qu. | unknown | NO | 17T | 628900E 4953900N | Orillia | XII | 9 | Huronia | N | 2.6 m | Gull River |
| H-26 | Longford Quarries | Longford Quarries Ltd. | NO | 17T | 631750E 4949500N | Rama | B.F. | 24-26 | Huronia | N | 9.0 m | Gull River, Bobcaygeon |
| H-27 | Burton Qy | T. Burton | YES | 17T | 643400E 4950350N | Rama | B | 17 | Huronia | I | <1.0 m | Gull River |

* Y = yes; N = no; I = intermittent

| Site No. | Quarry Name | Operator or Owner | MNR Lic | UTM | Coords | Township | Conc | Lot | MNR District | Active (*) | Thickness | Geological Formation(s) (Members) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| H-28 | Sebright Qy | M. Campbell | NO | 17T | 643800E 4949100N | Rama | A | 16 | Huronia | N | 4.4 m | Gull River, Bobcaygeon |
| H-29 | Uptergrove Qy | unknown | NO | 17T | 637800E 4941700N | Mara | X | 19 | Huronia |  | 0.0 m | Bobcaygeon |
| H-30 | Millington Qy | unknown | NO | 17T | 640800E 4939300N | Mara | VIII | 14 | Huronia | N | 0.5 m | Bobcaygeon |
| H-31 | MTC Qy | Ministry of Transportation | NO | 17T | 642100E 4838400N | Mara | VII | 12 | Huronia | N | unknown | Bobcaygeon |
| H-32 | Harrington (Udney) Qy | unknown | NO | 17T | 645250E 4941750N | Mara | IX | 6 | Huronia | N | 1.0 m | Gull River |
| H-33 | E Brechin Qy | unknown | NO | 17T | 648550E 4935500N | Mara | IV | 4 | Huronia | N | 0.5 m | Bobcaygeon |
| L-01 | Bowmanville Qy | St. Mary's Cement Co. | YES | 17T | 685350E 4868550N | Darlington | Broken Front | 12–17 | Lindsay | Y | 50.3 m | Lindsay (lower, Collingwood) |
| L-02 | Dalrymple Qy | Miller Paving Ltd. | YES | 17T | 650600E 4940850N | Carden | II–III | 8–12 | Minden | Y | 6.7 m | Bobcaygeon |
| L-03 | Carden Qy | Gormley Aggregates Ltd. | YES | 17T | 651000E 4936600N | Carden | I | 1–4 | Minden | Y | 20.0 m | Bobcaygeon, Verulam |
| L-04 | Coboconk E Qy | Cedarhurst Crush. & Qys | NO | 17T | 675000E 4947100N | Somerville | Front | 37 | Minden | Y | 9.5 m | Bobcaygeon |
| L-05 | Britnell Qy | unknown | NO | 17T | 682100E 4948200N | Somerville | VI | 13 | Minden | N | 7.3 m | Gull River |
| L-06 | Flynns Turn Qy | Nelson H. Windover | YES | 17T | 702900E 4941100N | Harvey | XIII | 21 | Minden | Y | 1.0 m | Gull River |
| L-07 | Harvey Qy | Ormell Sand & Gravel | YES | 17T | 708500E 4941300N | Harvey | IX | 17 | Lindsay | Y | 8.3 m | Gull River |
| L-08 | Buckhorn Qy | Nelson H. Windover | YES | 17T | 708800E 4938100N | Harvey | IX | 12 | Minden | Y | 2.0 m | Gull River |
| L-09 | Warsaw Qy | E. W. Payne | YES | 17T | 729850E 4930000N | Dummer | IV | 21 | Lindsay | Y | 0.5 m | Gull River |
| L-10 | Havelock Qy | Harnden & King Constr. | YES | 18T | 267250E 4924300N | Belmont | XI | 8–9 | Lindsay | I | 2.0 m | Bobcaygeon |
| L-11 | Old Bowmanville Qy | unknown | NO | 17T | 687000E 4863300N | Darlington | BF | 10 | Lindsay | N | unknown | Lindsay |
| L-12 | Cameron (Oakwood) Qy | Cameron | NO | 17T | 669500E 4915800N | Mariposa | XII | 19 | Lindsay | N | 3.1 m | Lindsay |
| L-13 | Kirkfield Qy | Kirkfield Crushed Stone | NO | 17T | 661200E 4938800N | Eldon | NPR | 50–52 | Lindsay | N | 3.0 m | Bobcaygeon, Verulam |
| L-14 | Kirkfield Qy # 2 | unknown | NO | 17T | 659100E 4939100N | Carden | VII | 2 | Minden | N | unknown | Bobcaygeon |
| L-15 | Corsons Qy | unknown | NO | 17T | 666950E 4943450N | Bexley | IV | 4 | Lindsay | N | 3.3 m | Bobcaygeon |
| L-16 | Norland Qy | unknown | NO | 17T | 673900E 4952000N | Laxton | XI | 1 | Minden | N | unknown | Gull River |
| L-17 | Coboconk W Qy | Toronto Lime Co. | NO | 17T | 674600E 4946800N | Somerville | Front | 36 | Minden | N | 6.0 m | Bobcaygeon |
| L-18 | Fell Qy | unknown | NO | 17T | 681200E 4943600N | Somerville | III | 17 | Minden | N | 5.0 m | Gull River |
| L-19 | Burnt River Qy | unknown | NO | 17T | 683100E 4946900N | Somerville | IV | 13 | Minden | N | unknown | Gull River |
| L-20 | Dongola Qy | unknown | NO | 17T | 678900E 4957000N | Somerville | XII | 13 | Minden | N | unknown | Gull River |
| L-21 | Dunsford (English) Qy | unknown | NO | 17T | 688300E 4923400N | Verulam | III | 2 | Lindsay | N | unknown | Verulam |
| L-22 | Little Bob Qy | unknown | NO | 17T | 695950E 4933700N | Verulam | XIX | 12 | Lindsay | N | 6.0 m | Bobcaygeon |
| L-23 | Windover Qy | H. Windover | NO | 17T | 707900E 4952900N | Cavendish | I | unknown | Minden | Y | 19.5 m | Gull River |
| L-24 | Rocky Point Qy | unknown | NO | 17T | 697000E 4936600N | Harvey | XVIII | 17 | Minden | N | unknown | Gull River |
| L-25 | Big Island Qy | unknown | NO | 17T | 698100E 4935950N | Harvey | XVII | 15 | Minden | N | unknown | Gull River |
| L-26 | Volturno Lake Qy | unknown | NO | 17T | 700100E 4946000N | Harvey | XIII | 30 | Minden | N | 2.9 m | Gull River |
| L-27 | Nogies Creek Quarries | Black River Limestone Products | NO | 17T | 700500E 4942000N | Harvey | XIV | 23 | Minden | N | 1.5 m | Gull River |
| L-28 | Lakehurst Qy | James Hutchinson | NO | 17T | 702200E 4931200N | Harvey | XVI | 5 | Minden | N | 8.1 m | Verulam, Bobcaygeon |
| L-29 | Buckhorn Quarries | unknown | NO | 17T | 709300E 4937750N | Harvey | IX | 12 | Minden | N | 2.0 m | Gull River |
| L-30 | Rockcroft Qy | Evan C. Traynor | YES | 17T | 708500E 4945900N | Harvey | VII | 25–26 | Minden | N | unknown | Gull River |
| L-31 | Reeves Qy | Elizabeth Reeves | NO | 17T | 715000E 4939900N | Harvey | V | 12 | Minden | N | 3.0 m | Gull River |
| L-32 | Burleigh Falls Qy | unknown | NO | 17T | 718850E 4939950N | Harvey | II | 11 | Minden | N | unknown | Gull River |
| L-33 | Telford Bay Qy | unknown | NO | 17T | 706400E 4917500N | Ennismore | III | 8 | Lindsay | N | 4.8 m | Verulam |
| L-34 | Peterborough Qy | City of Peterborough | NO | 17T | 715800E 4917200N | Smith | V | 23 | Lindsay | N | 12.0 m | Verulam |
| L-35 | Burleigh Falls Quarries | unknown | NO | 17T | 721900E 4936800N | Smith | XVI | 44 | Lindsay | N | unknown | Bobcaygeon |
| L-36 | Lakefield Qy | Canada Cement Co. Ltd. | NO | 17T | 718600E 4922400N | Douro | VII | 16 | Lindsay | N | 13.4 m | Verulam |
| L-37 | Brysons Bay Qy | unknown | NO | 17T | 723900E 4932950N | Dummer | I | 30 | Lindsay | N | unknown | Gull River |
| L-38 | Warsaw Qy #3 | unknown | NO | 17T | 728800E 4924400N | Dummer | II | 14 | Lindsay | N | 2.0 m | Gull River |
| L-39 | Warsaw Qy #2 | unknown | NO | 17T | 729200E 4929500N | Dummer | IV | 21 | Lindsay | N | 1.5 m | Gull River |
| L-40 | Warsaw Qy #1 | unknown | NO | 17T | 729050E 4930100N | Dummer | IV | 22 | Lindsay | N | 1.0 m | Gull River |
| L-41 | Warsaw Qy | K.J. Kostiuk | YES | 17T | 729450E 4930400N | Dummer | IV | 22 | Lindsay | I | 1.5 m | Gull River |
| L-42 | McCrakens Landing Qy | unknown | NO | 17T | 727100E 4935200N | Dummer | IV | 31 | Lindsay | N | unknown | Gull River |
| L-43 | Armstrong Qy | P. Armstrong | NO | 17T | 737200E 4938700N | Dummer | XII | 29 | Lindsay | N | 5.1 m | Gull River |
| L-44 | Bullied Qy | Larry Bullied | NO | 17T | 269800E 4939700N | Belmont | VI | 31 | Lindsay | N | 1.0 m | Gull River |
| L-45 | Havelock Qy | 3M Canada Ltd. | NO | 18T | 275100E 4924800N | Belmont | VI | 7 | Lindsay | N | 6.0 m | Gull River, Bobcaygeon |
| L-46 | Woodview Qy | unknown | NO | 17T | 725000E 4940500N | Burleigh | III | 7 | Bancroft | N | 5.0 m | Gull River |
| L-47 | Booth Qy | unknown | NO | 17T | 726100E 4941200N | Burleigh | IV | 7 | Bancroft | N | unknown | Gull River |
| MA-01 | Melville Hill Qy | unknown | NO | 17T | 574000E 4861800N | Caledon | I W | 29 | Maple | N | 12.0 m | Amabel |
| MA-02 | Wells Qy | S. Wells | NO | 17T | 575100E 4860850N | Caledon | I W | 27 | Maple | N | 11.0 m | Amabel |
| MA-03 | Saferi Qy | Mr. Saferi | NO | 17T | 575950E 4858000N | Caledon | II | 23 | Maple | N | 13.0 m | Amabel |

* Y = yes; N = no; I = intermittent

| Site No. | Quarry Name | Operator or Owner | MNR Lic | UTM | Coords | Township | Conc | Lot | MNR District | Active (*) | Thick-ness | Geological Formation(s) (Members) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MA-04 | Alton Qy | unknown | NO | 17T | 575350E 4855700N | Caledon | IV | 21 | Maple | N | 6.3 m | Amabel |
| MA-05 | Sleswick Qy | unknown | NO | 17T | 585300E 4864300N | Albion | I | 34 | Maple | N | unknown | Amabel |
| MA-06 | Cation (Speers) Qy | Cation, J.F. | NO | 17T | 584100E 4859500N | Caledon | IV EHS | 14 | Maple | N | 6.5 m | Amabel |
| MA-07 | Credit Forks Qy | unknown | NO | 17T | 580300E 4850550N | Caledon | IV | 9 | Maple | N | 6.7 m | Manitoulin |
| MA-08 | Deforest Qy | Deforest Brothers | YES | 17T | – – | Caledon | III W | 4–5 | Maple | Y | 3.0 m | Whirlpool, Manitoulin |
| MA-09 | Credit Valley Qy | H.M. Norrie | YES | 17T | – – | Caledon | III W | 1 | Maple | Y | 10.0 m | Whirlpool, Manitoulin |
| MO-01 | Labelle Qy | M.J. Labelle Co. Ltd. | NO | 17U | 520500E 5675000N | Horden | VIII | 7 | Moosonee | N | 12.2 m | Kwataboahegan |
| NI-01 | Lincoln Qy | Nelson Aggregate Co. | YES | 17T | 622800E 4773900N | Clinton | IX | 20 | Niagara | Y | 19.2 m | Lockport (Goat Island, Eramosa) |
| NI-02 | Vineland Qy #1 | Vineland Quarries & Crushed Stone | YES | 17T | 629000E 4777700N | Clinton | VI, VII | 1–4 | Niagara | Y | 9.0 m | Rochester, Decew, Lockport |
| NI-03 | Thorold Qy | Walker Brothers Quarries | YES | 17T | 648800E 4776500N | Stamford | X | 11, 30–31, 49–50, 66 | Niagara | Y | 9.8 m | Rochester, Decew, Lockport (Gasport) |
| NI-04 | Queenston Qy | Steetley Industries Ltd. | YES | 17T | 655300E 4779200N | Niagara | X | 44–45, 47–49 | Niagara | Y | 9.7 m | Rochester, Decew, Lockport(G.& G.Is) |
| NI-05 | Hagersville Quarries | Standard Aggregates | YES | 17T | 578400E 4757300N | Oneida | I Rge E. of Plank Rd | 28–29 | Niagara | Y | 16.4 m | Bertie(Akron),Bois Blanc(Springvale) |
| NI-06 | Abandoned Oneida Qy | Cayuga Mat. & Constr. | NO | 17T | 585450E 4756200N | Oneida | 1 N of Cayuga | 49 | Niagara | N | 4.1 m | Bertie, Oriskany |
| NI-07 | Oneida Qy | Nelson Aggregate Co. | YES | 17T | 586000E 4756250N | Oneida | I N of Cayuga | 48 | Niagara | N | 18.8 m | Bertie, Oriskany, Bois Blanc |
| NI-08 | Cayuga (Decewsville) Qy | Cayuga Mat. & Constr. | YES | 17T | 587400E 4754800N | N Cayuga | I N | 44–47 | Niagara | Y | 19.8 m | Bertie, Oriskany, Bois Blanc |
| NI-09 | Sweets Corners Quarries | unknown | NO | 17T | 595800E 4748400N | S Cayuga | IV | 31 | Niagara | N | 6.9 m | Bois Blanc, Onondaga |
| NI-10 | Dunnville Rock Products | Dunnville Rock Products | YES | 17T | 612900E 4748700N | Dunn | Earl Tract | 3, 6–8 | Niagara | Y | 11.7 m | Bertie(Akron),Bois Blanc(Springvale) |
| NI-11 | Port Colborne (Law) Qy | Hard Rock Paving | YES | 17T | 638700E 4750500N | Wainfleet | II | 3–5 | Niagara | Y | 17.9 m | Bertie, Bois Blanc |
| NI-12 | Port Colborne Qy | Port Colborne Quarries | YES | 17T | 644500E 4751700N | Humberstone | II | 19–22 new; 23–24 old | Niagara | Y | 15.3 m | Bertie (several members), Bois Blanc |
| NI-13 | Bertie Bay Qy | unknown | NO | 17T | 663500E 4750200N | Bertie | II Lake Erie Front | 12 | Niagara | N | 4.2 m | Onondaga (Clarence) |
| NI-14 | Ridgemount Qy #1 | Ridgemount Quarries | YES | 17T | 662700E 4752900N | Bertie | VIII | 3–4 | Niagara | N | 10.6 m | Bertie, Bois Blanc, Onondaga |
| NI-15 | Ridgemount Qy #2 | Ridgemount Quarries | YES | 17T | 662600E 4754300N | Bertie | VIII | 5–8 | Niagara | Y | 14.3 m | Bertie, Bois Blanc |
| NI-16 | Clinton Qy | Clinton Quarry Ltd. | YES | 17T | – – | Clinton | V, VI | 5–6 | Niagara | Y | 8.9 m | Rochester, Decew Lockport (G. & G. Is.) |
| NI-17 | E Clanbrassil Qy | Leonard | NO | 17T | 586050E 4758250N | Oneida | III | 25 | Niagara | N | 6.5 m | Bertie (Williamsville) |
| NI-18 | Nelles Corners Quarries | unknown-abandoned | NO | 17T | 586600E 4753300N | N Cayuga | XV | 48 & 49 | Niagara | N | 2.0 m | Bois Blanc |
| NI-19 | Decewsville NE Qy | unknown-abandoned | NO | 17T | 589500E 4754750N | N Cayuga | I N | 40 | Niagara | N | 5.0 m | Bertie |
| NI-20 | Kohler Road Qy | unknown-abandoned | NO | 17T | 591100E 4755200N | N Cayuga | I N | 36 | Niagara | N | 3.0 m | Bertie (Akron) |
| NI-21 | S Cayuga Qy | unknown | NO | 17T | 601700E 4747000N | S Cayuga | VI | 19 | Niagara | N | 2.2 m | Onondaga |
| NI-22 | Upper Qy | unknown | NO | 17T | 602700E 4750200N | S Cayuga | V | 14 | Niagara | N | 4.3 m | Bois Blanc |
| NI-23 | Onondaga (Byng) Qy | unknown | NO | 17T | 607600E 4748500N | Dunn | I N | 5 | Niagara | N | 4.1 m | Bois Blanc, Onondaga (Edgecliff) |
| NI-24 | Byng Qy | unknown | NO | 17T | 610000E 4749000N | Dunn | 1S | 11 | Niagara | N | 1.5 m | Bertie |
| NI-25 | Weber (Byng) Qy | unknown | NO | 17T | 612000E 4749100N | Dunn | Haldimand Tract | 19 | Niagara | N | 7.7 m | Bertie (Scajaquanda, Williamsville) |
| NI-26 | Byng Airport Qy | K.W. Ricker (owner) | NO | 17T | 614700E 4748600N | Dunn | II Sheehan Tract | 9–10 | Niagara | N | 1.5 m | Bois Blanc |
| NI-27 | Smively (Stromness) Qu. | Haldimand County | NO | 17T | 618200E 4747300N | Sherbrooke | III | 3 | Niagara | N | 4.0 m | Bertie, Bois Blanc |
| NI-28 | Metcalfe (Grimsby) Qy | unknown | NO | 17T | 616200E 4782700N | N Grimsby | II | 11–12 | Niagara | N | 4.4 m | Decew, Lockport (Gasport) |
| NI-29 | Grimsby Qy #1 | unknown | NO | 17T | 616000E 4782000N | N Grimsby | II | 10 | Niagara | N | unknown | Lockport |
| NI-30 | Grimsby Qy #2 | unknown | NO | 17T | 617100E 4781800N | N Grimsby | II | 8 | Niagara | N | 6.0 m | Lockport (Gasport) |
| NI-31 | Smithville Qy | unknown | NO | 17T | 618500E 4772500N | S Grimsby | IX | 8 | Niagara | N | 2.0 m | Lockport |
| NI-32 | Vineland Qy # 2 | Vineland Qys & Cr. St. | YES | 17T | 623200E 4773500N | Clinton | IX | 19 | Niagara | N | 6.0 m | Lockport (Eramosa) |
| NI-33 | Beamsville Qy #1 | unknown | NO | 17T | 625050E 4777500N | Clinton | VI | 14 | Niagara | N | 0 m | Lockport |
| NI-34 | Beamsville Qy #2 | unknown | NO | 17T | 624600E 4777600N | Clinton | VI | 15 | Niagara | N | unknown | Lockport |
| NI-35 | Beamsville Qy #3 | unknown | NO | 17T | 624800E 4777800N | Clinton | V | 15 | Niagara | N | unknown | Lockport |
| NI-36 | Beamsville Qy #4 | unknown | NO | 17T | 624400E 4778000N | Clinton | V | 16 | Niagara | N | 2.0 m | Lockport |
| NI-37 | Beamsville Qy #5 | unknown | NO | 17T | 623900E 4777900N | Clinton | V | 17 | Niagara | N | unknown | Lockport |
| NI-38 | Gibson (Beamsville) Qu. | County of Lincoln | NO | 17T | 625700E 4777600N | Clinton | VI | 12–13 | Niagara | N | 8.5 m | Decew, Lockport (Gasport) |
| NI-40 | Jordan Qy | unknown | NO | 17T | 630200E 4775900N | Clinton | VIII | 2 | Niagara | N | 7.0 m | Lockport |
| NI-41 | Balls Falls Quarries | unknown | NO | 17T | 632400E 4777300N | Louth | VI | 21 | Niagara | N | 3.3 m | Lockport (Gasport) |

* Y = yes; N = no; I = intermittent

| Site No. | Quarry Name | Operator or Owner | MNR Lic | UTM | Coords | Township | Conc | Lot | MNR District | Active (*) | Thick-ness | Geological Formation(s) (Members) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NI-42 | Rockway Qy #1 | unknown | NO | 17T | 635200E 4775300N | Louth | VII | 12 | Niagara | N | 2.0 m | Lockport |
| NI-43 | Rockway Falls Qy | Maple Leaf Gun Club | NO | 17T | 636000E 4774600N | Louth | VIII | 11 | Niagara | N | 4.3 m | Lockport (Gasport) |
| NI-44 | Rockway Qy #2 | owned by John Cairns | NO | 17T | 638800E 4773800N | Pelham | I | 4 | Niagara | N | 1.3 m | Lockport (Gasport) |
| NI-45 | Rathton Point Qy | unknown | NO | 17T | 637700E 4749700N | Wainfleet | I | 7 | Niagara | N | unknown | Onondaga |
| NI-46 | W Qy, Port Colborne | Canada Cement Co. | NO | 17T | 638000E 4749100N | Wainfleet | I | 5-6 | Niagara | N | 6.8 m | Onondaga (Edgecliff) |
| NI-47 | Reebs Bay Qy | unknown | NO | 17T | 639800E 4749250N | Wainfleet | I | 3 | Niagara | N | unknown | Onondaga |
| NI-48 | Sugar Loaf Qy | unknown | NO | 17T | 640300E 4749300N | Wainfleet | I | 1 | Niagara | N | unknown | Onondaga |
| NI-49 | Brock University Qy 1 | Brock University | NO | 17T | 641500E 4775300N | Grantham | X | 20 | Niagara | N | 3.7 m | Lockport (Gasport) |
| NI-50 | Brock Univ – Pub Qy | unknown | NO | 17T | 642200E 4775500N | Grantham | X | 18 | Niagara | N | 3.5 m | Decew, Lockport (Gasport) |
| NI-51 | Brock University Qy 2 | Brock University | NO | 17T | 642700E 4775700N | Grantham | X | 18 | Niagara | N | 7.0 m | Lockport (Gasport, Goat Island) |
| NI-52 | St. Catharines Qy | St. Catharines Crushed Stone | NO | 17T | 643500E 4775800N | Grantham | X | 16-17 | Niagara | N | 13.0 m | Rochester, Lockport (Gasport Goat Is) |
| NI-53 | St. David's Rd Qy # 1 | unknown | NO | 17T | 644400E 4775850N | Thorold | – | 21 | Niagara | N | 3.5 m | Goat Island |
| NI-54 | St. David's Rd Qy # 2 | unknown | NO | 17T | 644800E 4776000N | Thorold | – | 21 | Niagara | N | 2.0 m | Lockport (Goat Island) |
| NI-55 | Grantham Qy | unknown | NO | 17T | 649400E 4778500N | Grantham | X | 2 | Niagara | N | 4.3 m | Lockport (Gasport) |
| NI-56 | Thorold Tunnel Qy | unknown | NO | 17T | 647150E 4774600N | Thorold | – | 28 | Niagara | N | unknown | unknown |
| NI-57 | Thorold (Battle) Qy | Walker Brothers Quarries | NO | 17T | 648000E 4776500N | Thorold | – | 43-45 | Niagara | N | 0.0 m | Decew, Lockport (Gasport) |
| NI-58 | Mountain Road Qy | unknown | NO | 17 T | 650500E 4777900N | Stamford | – | 8 | Niagara | N | 2.0 m | Irodequoit |
| NI-59 | St. Davids Qy | unknown | NO | 17T | 652100E 477888N | Niagara | – | 138 | Niagara | N | 0.0 m | Lockport |
| NI-60 | Town of Queenston Qy #2 | unknown | NO | 17T | 654900E 4779400N | Niagara | – | 91 | Niagara | N | 4.0 m | Lockport (Gasport) |
| NI-61 | Town of Queenston Qy #1 | unknown | NO | 17T | 657700E 4780200N | Niagara | – | 43 | Niagara | N | 4.2 m | Lockport (Gasport) |
| NI-62 | E Qy, Port Colborne | Canada Cement Co. | NO | 17T | 640600E 4749500N | Humberstone | I | 33 | Niagara | N | 4.8 m | Onondaga (Edgecliff) |
| NI-63 | Port Colborne Qy # 2 | unknown | NO | 17T | 642400E 4750000N | Humberstone | I | 29 | Niagara | N | unknown | Onondaga |
| NI-64 | Hogan's Qy | unknown | NO | 17T | 642300E 4749300N | Humberstone | I | 29 | Niagara | N | 5.0 m | Onondaga |
| NI-65 | Port Colborne Qy # 3 | unknown | NO | 17T | 644000E 4748600N | Humberstone | I | 25 | Niagara | N | unknown | Onondaga |
| NI-66 | Port Colborne Qy # 4 | unknown | NO | 17T | 644700E 4750600N | Humberstone | II | 20 | Niagara | N | 0.5 m | Onondaga |
| NI-67 | Humberstone County Qy | Welland County | NO | 17T | 646250E 4753400N | Humberstone | III | 19 | Niagara | N | 8.0 m | Bertie, Bois Blanc |
| NI-68 | Bethel Qy | unknown | NO | 17T | 646800E 4754150N | Humberstone | III | 18 | Niagara | N | 0.0 m | Bois Blanc |
| NI-69 | Shisler Point Qy | Sherkston Beach Ltd. | NO | 17T | 652600E 4748100N | Humberstone | I | 4-5 | Niagara | N | 5.7 m | Onondaga (Edgecliff) |
| NI-70 | Sherkston N Qy | unknown | NO | 17T | 652600E 4749300N | Humberstone | I | 4 | Niagara | N | 2.8 m | Onondaga (Clarence) |
| NI-71 | Ridgewood Qy | Township of Bertie (ex) | NO | 17T | 659700E 4751700N | Bertie | III Lake Erie Front | 21 | Niagara | N | 1.8 m | Bertie |
| NI-72 | Ridgewood Qy #2 | unknown | NO | 17T | 659850E 4752150N | Bertie | X | 1 | Niagara | N | 8.0 m | Bertie |
| NI-73 | Windmill Point Qy | Coast & Lake Constr. | NO | 17T | 662800E 4749500N | Bertie | I Lake Erie Front | 14 | Niagara | N | 3.0 m | Onondaga (Clarence) |
| NI-74 | Windmill Point Qy #2 | Windmill Point Crushed Stone | NO | 17T | 663200E 4749600N | Bertie | I Lake Erie Front | 13 | Niagara | N | 1.7 m | Onondaga (Edgecliff) |
| NI-75 | Buel Quarries | unknown | NO | 17T | 663500E 4750000N | Bertie | II Lake Erie Front | 12 | Niagara | N | 2.0 m | Onondaga (Edgecliff) |
| NI-76 | Ridgemount Qy # 3 | Ridgemount Quarries | YES | 17T | 663200E 4754800N | Bertie | VII | 8 | Niagara | N | 4.2 m | Bertie (Will., Akron), Bois Blanc |
| NI-77 | Woehl Qy | George Woehl | NO | 17T | 665500E 4754200N | Bertie | V | 6 | Niagara | N | 2.0 m | Bois Blanc |
| NI-78 | W Clanbrassil Qy | Christensen (Lewis) | NO | 17T | 585900E 4758250N | Oneida | III | 24 | Niagara | N | 6.9 m | Bertie (Falk., Scaj., Williamsville) |
| NP-01 | Ogden Point Qy | St. Lawrence Cement | YES | 18T | 268900E 4873700N | Cramahe | BF I | 29-35 | Napanee | Y | 40.0 m | Verulam, Lindsay |
| NP-02 | Consecon Qy | Trenton Gravel Products | YES | 18T | 298900E 4872250N | Hillier | V Bayside | 107 | Napanee | I | 11.2 m | Lindsay |
| NP-03 | Mountain View Qy | H.J. McFarland Constr. | YES | 18T | 311500E 4883000N | Ameliasburgh | IV | 64-65 | Napanee | I | 8.4 m | Lindsay |
| NP-04 | Cannifton Qy | Harvey Putnam/ Cannifton Quarries | YES | 18T | 310300E 4897400N | Thurlow | III | 10 | Napanee | Y | 6.2 m | Verulam |
| NP-05 | Point Anne Qy | Lafarge Canada/ McFarland-operator | YES | 18T | 317000E 4892750N | Thurlow | Broken Front & I | 16-27 | Napanee | I | 30.0 m | Gull River, Bobcaygeon |
| NP-06 | Long Qy | H.J. McFarland Constr. | YES | 18T | 320000E 4901650N | Tyendinaga | III | 6 | Napanee | Y | 6.7 m | Verulam |
| NP-07 | Picton Qy | Lake Ontario Cement | YES | 18T | 329750E 4879250N | Sophiasburgh | I SW of Green Point | 13-18 | Napanee | Y | 54.0 m | Verulam, Lindsay |
| NP-08 | Picton Qy | Miller Paving Ltd. | YES | 18T | 331000E 4881500N | Sophiasburgh | I | 19-20 | Napanee | Y | 6.4 m | Lindsay |
| NP-09 | Napanee Qy | Trenton Gravel Products | NO | 18T | 340900E 4898300N | Richmond | I | 12 | Napanee | Y | 7.0 m | Verulam |
| NP-10 | Roblindale Qy | H. J. McFarland Constr. | NO | 18T | 339900E 4915250N | Camden East | VI | 1 | Napanee | N | 18.3 m | Gull River, Bobcaygeon |
| NP-11 | Selby Qy | Custom Mobile Concrete | NO | 18T | 341800E 4905800N | Richmond | III | 21 | Napanee | Y | 6.0 m | Verulam |
| NP-12 | Napanee Qy | J.R. Storey Constr. | NO | 18T | 345200E 4002500N | N Fredericksburgh | VII | 19 | Napanee | Y | 16.0 m | Gull River |
| NP-13 | Napanee Qy | J.C. Denison | NO | 18T | 345500E 4901600N | N Fredericksburgh | VII | 21 | Napanee | Y | 7.5 m | Gull River |

* Y = yes; N = no; I = intermittent

| Site No. | Quarry Name | Operator or Owner | MNR Lic | UTM | Coords | Township | Conc | Lot | MNR District | Active (*) | Thick-ness | Geological Formation(s) (Members) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NP-14 | Dillon Qy | Griffin Bros. Gananoque | NO | 18T | 353300E 4928800N | Camden East | N:IX, S:VIII | N:49, S:49 | Napanee | Y | 6.6 m | Gull River |
| NP-15 | Camden E (Aylesworth) | Township of Camden E. | NO | 18T | 352600E 4912700N | Camden East | II | 26 | Napanee | I | 7.0 m | Gull River |
| NP-16 | Morven Qy | J.R. Storey Constr. | NO | 18T | 353400E 4902300N | Ernestown | V | 9 | Napanee | Y | 4.2 m | Gull River |
| NP-17 | Storms Corners | J.C. Denison | NO | 18T | 355400E 4901100N | Ernestown | IV | 12–13 | Napanee | Y | 10.0 m | Gull River |
| NP-18 | Bath Qy | Lafarge Canada Inc | NO | 18T | 355600E 4892100N | Ernestown | I | 3–4 | Napanee | Y | 17.7 m | Verulam |
| NP-19 | Wilton Qy | F.G. Bezanson & Son | NO | 18T | 362800E 4908200N | Ernestown | VI | 36 | Napanee | Y | 11.0 m | Gull River |
| NP-20 | Caughey – Amherst Is | Township of Amherst Is. | NO | 18T | 366000E 4892800N | Amherst Island | N Shore | 9 | Napanee | I | 9.3 m | Verulam |
| NP-21 | Hartington Qy | Portland Twp. | NO | 18T | 369200E 4922000N | Portland | VII | 3 | Napanee | Y | 10.0 m | Gull River |
| NP-22 | Westbrook Qy | W.J. McKendry & Sons | YES | 18T | 368875E 4901450N | Kingston | Miles Square Block |  | Napanee | I | 6.0 m | Gull River |
| NP-23 | Collins Bay Qy | Woods Sand & Gravel | YES | 18T | 371500E 4902000N | Kingston | III | 2–3 | Napanee | Y | 36.0 m | Gull River |
| NP-24 | Kingston Qy | H. J. McFarland Constr. | YES | 18T | 374000E 4904000N | Kingston | IV | 9 | Napanee | I | 10.4 m | Bobcaygeon |
| NP-25 | Kingston Qy | Township of Kingston | YES | 18T | 375000E 4904100N | Kingston | IV | 11–12 | Napanee | I | 9.0 m | Bobcaygeon |
| NP-26 | Kepler (Cranston) Qy | W.J. McKendry & Sons | NO | 18T | 374500E 4913400N | Loughborough | I | 6 | Napanee | I | 9.0 m | Gull River |
| NP-27 | Elginburg Qy | Frontenac Aggregates | YES | 18T | 375900E 4907750N | Kingston | V | 14–15 | Napanee | Y | 10.0 m | Gull River |
| NP-28 | Spaffordton Qy | Loughborough Township | NO | 18T | 379300E 4918300N | Loughborough | V | 14 | Napanee | I | 8.3 m | Gull River |
| NP-29 | Kingston Qy | W.J. McKendry & Sons | YES | 18T | 379000E 4906800N | Kingston | V | 24 | Napanee | Y | 15.9 m | Gull River |
| NP-30 | Macadoos Lane Qy | Woods Sand & Gravel | YES | 18T | 380200E 4904400N | Kingston | IV | 26 | Napanee | Y | 17.0 m | Gull River |
| NP-31 | Macadoos Lane (Bilow) Qy | H. J. McFarland Constr. | YES | 18T | 380900E 4904900N | Kingston | IV | 28–29 | Napanee | I | 9.4 m | Gull River |
| NP-32 | Pittsburg Qy | Frontenac Aggr. & Constr. | YES | 18T | 383600E 4902200N | Pittsburgh | E of Cataraqui R. | 7–8 | Napanee | Y | 20.6 m | Gull River |
| NP-33 | Mill Point | unknown | NO | 18T | 383250E 4993400N | Wolfe Island | Registered Plan 73 | 10–11 | Napanee | I | 8.0 m | Gull River |
| NP-34 | Battersea Qy | Griffin Bros. /Twp. of Storrington | YES | 18T | 388000E 4918000N | Storrington | VIII | 5 | Napanee | Y | 5.5 m | Gull River |
| NP-35 | Joyceville Qy | Griffin Bros. Gananoque | YES | 18T | 393150E 4912050N | Pittsburgh | V | 17–18 | Napanee | I | 13.5 m | Gull River |
| NP-36 | Howe Island Qy # 1 | unknown | NO | 18T | 394500E 4901800N | Howe Island | N Range | 5 | Napanee | I | 3.0 m | Gull River |
| NP-37 | Westbrook Qy | Warren Paving & Mat. | YES | 18T | 370050E 4905500N | Kingston | IV W Division | 1–3 | Napanee | Y | 5.0 m | Gull River |
| NP-39 | Campbellford Qy | unknown | NO | 18T | 275600E 4905800N | Seymour | IV | 7 | Napanee | N | 1.0 m | Verulam |
| NP-40 | Springbrook Qy | unknown | NO | 18T | 292800E 4917250N | Rawdon | VIII | 12 | Napanee | N | 8.5 m | Bobcaygeon, Verulam |
| NP-41 | Wellman Qy # 1 | unknown | NO | 18T | 290400E 4911800N | Rawdon | IV | 18 | Napanee | N | 2.0 m | Verulam |
| NP-42 | Wellman Qy # 2 | unknown | NO | 18T | 292000E 4910800N | Rawdon | IV | 17 | Napanee | N | 0.0 m | Verulam |
| NP-43 | Stirling Qy | unknown | NO | 18T | 295300E 4907300N | Rawdon | I | 16 | Napanee | N | 2.0 m | Verulam |
| NP-44 | Gosport Qy | unknown | NO | 18T | 282200E 4877700N | Brighton | B | 33 | Napanee | N | 0.0 m | Lindsay |
| NP-45 | Miron Qy | L. Miron | NO | 18T | 289550E 4889300N | Murray | III | 9 | Napanee | N | 0.5 m | Verulam |
| NP-46 | McCauley Qy | unknown | NO | 18T | 292400E 4890900N | Murray | III | 2 | Napanee | N | unknown | Verulam |
| NP-47 | Chatterton Qy | unknown | NO | 18T | 303150E 4902350N | Sidney | VI | 34 | Napanee | N | unknown | Verulam |
| NP-48 | Bayside Qy | Hastings Board of Ed. | NO | 18T | 301450E 4889400N | Sidney | I | 19 | Napanee | N | 6.0 m | Verulam |
| NP-49 | Foxboro Qy | Township of Thurlow | NO | 18T | 305250E 4903300N | Thurlow | VI | 2 | Napanee | N | 4.6 m | Bobcaygeon |
| NP-50 | Honeywell Corners Qy | unknown | NO | 18T | 310500E 4902000N | Thurlow | V | 13 | Napanee | N | <0.5 m | Verulam |
| NP-51 | Cannifton Qy # 2 | unknown | NO | 18T | 308200E 4896500N | Thurlow | III | 4 | Napanee | N | 5.0 m | Verulam |
| NP-52 | Belleville Qy # 1 | unknown | NO | 18T | 308500E 4894750N | Thurlow | II | 3 | Napanee | N | 0.0 m | Verulam |
| NP-53 | Cannifton Qy | unknown | NO | 18T | 308750E 4895800N | Thurlow | II | 5 | Napanee | N | 6.0 m | Verulam |
| NP-54 | Belleville Qy # 2 | unknown | NO | 18T | 310300E 4895100N | Thurlow | II | 8 | Napanee | N | 0.0 m | Verulam |
| NP-55 | Thurlow Qy | unknown | NO | 18T | 316050E 4898050N | Thurlow | II | 25 | Napanee | N | unknown | Verulam |
| NP-56 | Honeywell Corners Qy | Gerald O'Neill Ltd. | YES | 18T | 318000E 4900000N | Thurlow | III | 31 | Napanee | N | 4.0 m | Verulam |
| NP-57 | Ox Point Qy # 1 | unknown | NO | 18T | 315300E 4891600N | Thurlow | Broken Front | 18 | Napanee | N | 6.0 m | Bobcaygeon |
| NP-58 | Ox Point Qy # 2 | unknown | NO | 18T | 315250E 4891650N | Thurlow | Broken Front | 18 | Napanee | N | 4.0 m | Bobcaygeon |
| NP-59 | Point Anne Qy # 2 | unknown | NO | 18T | 316100E 4892100N | Thurlow | Broken Front | 20 | Napanee | N | 5.0 m | Bobcaygeon |
| NP-60 | Point Anne Qy # 1 | unknown | NO | 18T | 316000E 4891750N | Thurlow | Broken Front | 20 | Napanee | N | 4.0 m | Bobcaygeon |
| NP-61 | Read Qy | unknown | NO | 18T | 324625E 4908600N | Tyendinaga | VI | 21 | Napanee | N | 4.6 m | Bobcaygeon |
| NP-62 | Melrose Qy # 2 | unknown | NO | 18T | 322650E 4904000N | Tyendinaga | IV | 12 | Napanee | N | unknown | Bobcaygeon |
| NP-63 | Melrose Qy # 1 | unknown | NO | 18T | 323050E 4905050N | Tyendinaga | IV | 16 | Napanee | N | unknown | Bobcaygeon |
| NP-64 | Lonsdale Qy | unknown | NO | 18T | 330050E 4904050N | Tyendinaga | III | 31 | Napanee | N | unknown | Gull River |
| NP-65 | McGrogan Qy | W. McGrogan | NO | 18T | 319350E 4898150N | Tyendinaga | I | 1 | Napanee | N | 0.0 m | Bobcaygeon |
| NP-66 | Milltown Qy | H.J. McFarland Constr. | NO | 18T | 323000E 4898700N | Tyendinaga | I | 11 | Napanee | N | 2.7 m | Verulam |
| NP-67 | Marysville Qy # 2 | H.J. McFarland Constr. | YES | 18T | 326800E 4898500N | Tyendinaga | I | 19 | Napanee | I | 7.0 m | Bobcaygeon |
| NP-68 | Shannonville Qy | Ontario Limestone & Clay | NO | 18T | 320300E 4894700N | Tyendinaga | III IR 18 | 1–2 | Napanee | N | unknown | Gull River |

* Y = yes; N = no; I = intermittent

| Site No. | Quarry Name | Operator or Owner | MNR Lic | UTM | Coords | Township | Conc | Lot | MNR District | Active (*) | Thick-ness | Geological Formation(s) (Members) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NP-69 | Shannonville Qy | unknown | NO | 18T | 322100E 4894900N | Tyendinaga | II | 6 | Napanee | N | 1.0 m | Bobcaygeon |
| NP-70 | Deseronto Airport Qy | unknown | NO | 18T | 332500E 4893800N | Tyendinaga | III IR 18 | 29 | Napanee | N | unknown | Verulam |
| NP-71 | Deseronto Qy # 2 | unknown | NO | 18T | 335250E 4994950N | Tyendinaga | I | 36 | Napanee | N | 0.0 m | Verulam |
| NP-72 | Deseronto Qy # 1 | unknown | NO | 18T | 336000E 4897450N | Tyendinaga | I | 40 | Napanee | N | unknown | Verulam |
| NP-73 | Gardenville Qy | unknown | NO | 18T | 292300E 4879050N | Ameliasburgh | SW of Carrying Pl Rd | 2 | Napanee | N | 0.0 m | Verulam |
| NP-74 | Carrying Place Qy | unknown | NO | 18T | 293995E 4880600N | Ameliasburgh | SW of Carrying Pl Rd | 13 | Napanee | N | 2.0 m | Lindsay |
| NP-75 | Albury Qy | unknown | NO | 18T | 296700E 4881600N | Ameliasburgh | I | 99 | Napanee | N | 1.0 m | Lindsay |
| NP-76 | Rossmore Qy # 1 | unknown | NO | 18T | 307900E 4889000N | Ameliasburgh | I | 65 | Napanee | N | 0.0 m | Verulam |
| NP-77 | Bates Qy | W. Bates | NO | 18T | 309000E 4888300N | Ameliasburgh | I | 63 | Napanee | N | unknown | Verulam |
| NP-78 | Rossmore Qy # 2 | unknown | NO | 18T | 309500E 4889800N | Ameliasburgh | I | 60 | Napanee | N | 0.0 m | Verulam |
| NP-79 | Massasauga Point Qy | unknown | NO | 18T | 315200E 4890500N | Ameliasburgh | II | – | Napanee | N | 16.5 m | Bobcaygeon, Verulam |
| NP-80 | Consecon Qy # 2 | unknown | NO | 18T | 298750E 4872150N | Hillier | V Bayside | 108 | Napanee | N | 7.0 m | Lindsay |
| NP-81 | Niles Corners Qy # 1 | unknown | NO | 18T | 306200E 4871600N | Hillier | II | 13 | Napanee | N | 1.0 m | Lindsay |
| NP-82 | Niles Corners Qy # 2 | unknown | NO | 18T | 309000E 4871800N | Hillier | II | 6 | Napanee | N | 0.0 m | Lindsay |
| NP-83 | Wellington Qy # 1 | unknown | NO | 18T | 310400E 4871300N | Hillier | I | 4 | Napanee | N | 0.0 m | Lindsay |
| NP-84 | Wellington Qy # 2 | unknown | NO | 18T | 311200E 4872200N | Hillier | II | 1 | Napanee | N | 0.5 m | Lindsay |
| NP-85 | Melville Qy | unknown | NO | 18T | 306700E 4877600N | Hillier | V | 83 | Napanee | N | 2.0 m | Lindsay |
| NP-86 | Burr Qy | unknown | NO | 18T | 309200E 4879400N | Hillier | V | 75 | Napanee | N | 1.0 m | Lindsay |
| NP-87 | Crofton Qy | unknown | NO | 18T | 313050E 4882900N | Sophiasburgh | I Broken Front | 62 | Napanee | N | 4.0 m | Lindsay |
| NP-88 | Redner Qy | J. Redner | NO | 18T | 315000E 4881100N | Sophiasburgh | II Broken Front | 60 | Napanee | N | 0.5 m | Lindsay |
| NP-90 | Gilbert Mills Qy # 1 | unknown | NO | 18T | 319100E 4880650N | Sophiasburgh | II W of Green Point | 52 | Napanee | N | 0.0 m | Lindsay |
| NP-91 | Desmorestville Qy | Twp. of Sophiasburgh | YES | 18T | 323100E 4883800N | Sophiasburgh | I | 39 | Napanee | I | 3.8 m | Lindsay |
| NP-92 | Desmorestville Qy # 2 | unknown | NO | 18T | 324350E 4882950N | Sophiasburgh | II W of Green Point | 38 | Napanee | N | 0.5 m | Lindsay |
| NP-93 | N Port Qy | unknown | NO | 18T | 325500E 4888400N | Sophiasburgh | I W of Green Point | 27 | Napanee | N | 2.5 m | Verulam |
| NP-94 | Desmorestville Qy # 3 | unknown | NO | 18T | 326500E 4883600N | Sophiasburgh | II W of Green Point | 32 | Napanee | N | 0.0 m | Lindsay |
| NP-95 | Bethesda Qy # 2 | unknown | NO | 18T | 327950E 4883500N | Sophiasburgh | II SW of Green Point | 21 | Napanee | N | 1.0 m | Lindsay |
| NP-96 | Bethesda Qy # 1 | unknown | NO | 18T | 329500E 4884300N | Sophiasburgh | Gore B | – | Napanee | N | 0.5 m | Lindsay |
| NP-97 | Bethesda Qy # 3 | unknown | NO | 18T | 330950E 4885500N | Sophiasburgh | I SW of Green Point | 29 | Napanee | N | unknown | Lindsay |
| NP-98 | Woodville Qy | unknown | NO | 18T | 332400E 4883000N | Sophiasburgh | I SW of Green Point | 25 | Napanee | N | 1.0 m | Lindsay |
| NP-99 | Solmesville Qy | unknown | NO | 18T | 331500E 4891150N | Sophiasburgh | I W of Green Point | 10 | Napanee | N | unknown | Verulam |
| NP-100 | Green Point Qy | unknown | NO | 18T | 332600E 4892150N | Sophiasburgh | VIII Gore | 1 | Napanee | N | unknown | Verulam |
| NP-101 | Mount Carmel Qy | H.J. McFarland Constr. | NO | 18T | 333300E 4888300N | Sophiasburgh | I SW of Green Point | 38 | Napanee | N | 6.0 m | Lindsay |
| NP-102 | Huff's Corners Qy # 1 | unknown | NO | 18T | 316500E 4876100N | Hallowell | Irvine Gore | 65 | Napanee | N | 2.0 m | Lindsay |
| NP-103 | Huff's Corners Qy # 2 | unknown | NO | 18T | 316900E 4875400N | Hallowell | Irvine Gore | 65 | Napanee | N | 1.0 m | Lindsay |
| NP-104 | Gilbert Mills Qy # 2 | unknown | NO | 18T | 321200E 4877200N | Hallowell | Gerow Gore | 53 | Napanee | N | 0.5 m | Lindsay |
| NP-105 | Bloomfield Qy # 1 | unknown | NO | 18T | 320300E 4874800N | Hallowell | II Military Tract | 5 | Napanee | N | 0.5 m | Lindsay |
| NP-106 | Bloomfield Qy # 2 | unknown | NO | 18T | 320000E 4872650N | Hallowell | I Military Tract | 1 | Napanee | N | 0.0 m | Lindsay |
| NP-107 | Yerexville Qy # 1 | unknown | NO | 18T | 324000E 4876000N | Hallowell | III Military Tract | 13 | Napanee | N | 0.0 m | Lindsay |
| NP-108 | Yerexville Qy # 2 | unknown | NO | 18T | 323950E 4875800N | Hallowell | III Military Tract | 13 | Napanee | N | 0.0 m | Lindsay |
| NP-109 | Picton Qy # 3 | unknown | NO | 18T | 327600E 4878600N | Hallowell | II NW of Carrying Pl | 9 | Napanee | N | 0.9 m | Lindsay |
| NP-110 | Picton Qy # 4 | unknown | NO | 18T | 327900E 4878800N | Hallowell | I NW of Carrying Pl. | 10 | Napanee | N | 1.5 m | Lindsay |
| NP-111 | Yerexville Qy # 3 | unknown | NO | 18T | 327300E 4877700N | Hallowell | I NW of Carrying Pl | 7 | Napanee | N | 0.0 m | Lindsay |
| NP-112 | Bedborough Qy | unknown | NO | 18T | 327050E 4872800N | Hallowell | II Military Tract | 23 | Napanee | N | 3.0 m | Lindsay |
| NP-113 | Picton Landfill | unknown | NO | 18T | 329000E 4874300N | Hallowell | I SE of Carrying Pl. | 22 | Napanee | N | 20.0 m | Verulam, Lindsay |
| NP-114 | Picton Qy # 5 | unknown | NO | 18T | 329600E 4874600N | Hallowell | SE of Carrying Place | 20 | Napanee | N | 1.0 m | Verulam |

* Y = yes; N = no; I = intermittent

| Site No. | Quarry Name | Operator or Owner | MNR Lic | UTM | Coords | Township | Conc | Lot | MNR District | Active (*) | Thick-ness | Geological Formation(s) (Members) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NP-115 | Picton Qy # 6 | unknown | NO | 18T | 331500E 4875300N | Hallowell | Gore K | – | Napanee | N | 0.5 m | Lindsay |
| NP-116 | Picton Qy # 7 | unknown | NO | 18T | 331800E 4875200N | Hallowell | Gore K | – | Napanee | N | unknown | Lindsay |
| NP-117 | Picton Qy # 8 | unknown | NO | 18T | 330550E 4874400N | Hallowell | SE of Carrying Place | 21 | Napanee | N | 1.0 m | Lindsay |
| NP-118 | Picton Qy # 9 | unknown | NO | 18T | 330900E 4874250N | Hallowell | Gore K | – | Napanee | N | 0.0 m | Lindsay |
| NP-119 | Cherry Valley Qy # 4 | unknown | NO | 18T | 324900E 4868200N | Athol | N of E Lake | 15 | Napanee | N | 0.0 m | Lindsay |
| NP-120 | Cherry Valley Qy # 3 | unknown | NO | 18T | 327000E 4868500N | Athol | E of E Lake | 3 | Napanee | N | 0.0 m | Lindsay |
| NP-121 | Cherry Valley Qy # 2 | unknown | NO | 18T | 327650E 4867300N | Athol | E of E Lake | 6 | Napanee | N | unknown | Lindsay |
| NP-122 | Cherry Valley Qy # 1 | unknown | NO | 18T | 327500E 4864800N | Athol | II | 4 | Napanee | N | unknown | Lindsay |
| NP-123 | Milford Qy # 4 | unknown | NO | 18T | 328500E 4864500N | Athol | II | 3 | Napanee | N | <1.0 m | Lindsay |
| NP-124 | Milford Qy # 1 | unknown | NO | 18T | 330000E 4865500N | S Marysburgh | I N of Black River | 31 | Napanee | N | 0.5 m | Lindsay |
| NP-125 | Milford Qy # 2 | unknown | NO | 18T | 332750E 4869000N | S Marysburgh | I N of Black River | 20 | Napanee | N | 0.0 m | Lindsay |
| NP-126 | Black River Bridge Qy | unknown | NO | 18T | 335700E 4869900N | S Marysburgh | I N of Black River | 12 | Napanee | N | 0.0 m | Lindsay |
| NP-127 | Port Milford Qy | unknown | NO | 18T | 335750E 4867250N | S Marysburgh | Round Pr Edward Bay | 25 | Napanee | N | 2.2 m | Lindsay |
| NP-128 | Milford Qy # 3 | unknown | NO | 18T | 333800E 4864250N | S Marysburgh | I S of Black River | 24 | Napanee | N | 1.0 m | Lindsay |
| NP-129 | Waupoos Qy # 2 | unknown | NO | 18T | 337700E 4874100N | N Marysburgh | N of S Bay | 2 | Napanee | N | 2.0 m | Lindsay |
| NP-130 | Waupoos Qy | Harold Wilkinson | YES | 18T | 338000E 4873750N | N Marysburgh | Lakeside N. of Smith | 2 | Napanee | N | 3.5 m | Verulam, Lindsay |
| NP-131 | Bongard Corners Qy | unknown | NO | 18T | 346500E 4881400N | N Marysburgh | Bayside | 41 | Napanee | N | unknown | Lindsay |
| NP-132 | Marys Cove Qy | unknown | NO | 18T | 347400E 4877850N | N Marysburgh | Ordance Reserve | 6 | Napanee | N | 2.0 m | Lindsay |
| NP-133 | Roblin Qy | unknown | NO | 18T | 338400E 4916600N | Richmond | IX | 21 | Napanee | N | 3.0 m | Bobcaygeon |
| NP-134 | Richmond Township Qy | unknown | NO | 18T | 340100E 4911400N | Richmond | VII | 21 | Napanee | N | 6.8 m | Gull River, Bobcaygeon |
| NP-135 | Selby Qy # 1 | unknown | NO | 18T | 341500E 4907450N | Richmond | IV | 21 | Napanee | N | unknown | Bobcaygeon |
| NP-136 | Selby Qy # 4 | unknown | NO | 18T | 340400E 4906400N | Richmond | IV | 17 | Napanee | N | unknown | Bobcaygeon |
| NP-137 | Selby Qy # 3 | unknown | NO | 18T | 340500E 4906500N | Richmond | IV | 18 | Napanee | N | unknown | Bobcaygeon |
| NP-138 | Selby Qy # 2 | unknown | NO | 18T | 340750E 4906350N | Richmond | III | 18 | Napanee | N | unknown | Bobcaygeon |
| NP-139 | Marysville Qy # 1 | H.J. McFarland Constr. | NO | 18T | 336000E 4901300N | Richmond | III | 3 | Napanee | N | 7.0 m | Verulam |
| NP-140 | Napanee Qy # 4 | H.J. McFarland Constr. | NO | 18T | 344100E 4903300N | Richmond | III | 24 | Napanee | N | 2.3 m | Bobcaygeon |
| NP-141 | Pybus Qy | unknown | NO | 18T | 344150E 4903200N | Richmond | I Gore | 30 | Napanee | N | 3.5 m | Gull River |
| NP-142 | Gretna Qy # 1 | unknown | NO | 18T | 340700E 4893700N | N Fredericks-burgh | V Additional | 1 | Napanee | N | unknown | Verulam |
| NP-143 | Gretna Qy # 2 | unknown | NO | 18T | 340900E 4894800N | N Fredericks-burgh | IV | 1 | Napanee | N | unknown | Bobcaygeon |
| NP-144 | Napanee Qy # 5 | unknown | NO | 18T | 342750E 4896900N | N Fredericks-burgh | IV | 9 | Napanee | N | 2.0 m | Bobcaygeon |
| NP-145 | Bergin Qy | unknown | NO | 18T | 345000E 4900400N | N Fredericks-burgh | VII | 18 | Napanee | N | unknown | Gull River |
| NP-146 | Kinkley Qy | H. Kinkley | NO | 18T | 345150E 4901200N | N Fredericks-burgh | VII | 19 | Napanee | N | 8.8 m | Gull River |
| NP-147 | Napanee Qy # 6 | unknown | NO | 18T | 348300E 4902100N | N Fredericks-burgh | VII | 27 | Napanee | N | unknown | Gull River |
| NP-148 | Napanee Qy | unknown | NO | 18T | 347100E 4898900N | N Fredericks-burgh | VI | 19 | Napanee | N | 6.0 m | Gull River |
| NP-149 | Napanee Qy # 8 | unknown | NO | 18T | 350000E 4897250N | N Fredericks-burgh | IV | 23 | Napanee | N | 1.0 m | Verulam |
| NP-150 | Napanee Qy # 9 | unknown | NO | 18T | 347500E 4904200N | N Fredericks-burgh | VII | 28 | Napanee | N | unknown | Gull River |
| NP-151 | Napanee Qy # 10 | unknown | NO | 18T | 348000E 4903990N | N Fredericks-burgh | VII | 29 | Napanee | N | unknown | Gull River |
| NP-152 | Adulphostown Qy | unknown | NO | 18T | 339800E 4886700N | S Fredericks-burgh | III Additional | 13 | Napanee | N | 4.0 m | Verulam |
| NP-153 | Sandhurst Qy # 1 | unknown | NO | 18T | 344600E 4888500N | S Fredericks-burgh | II | 1 | Napanee | N | 2.0 m | Verulam |
| NP-154 | Sandhurst Qy # 2 | unknown | NO | 18T | 345900E 4889400N | S Fredericks-burgh | II | 5 | Napanee | N | 2.0 m | Verulam |
| NP-155 | Sandhurst Qy # 3 | unknown | NO | 18T | 347500E 4887000N | S Fredericks-burgh | I | 5 | Napanee | N | 0.0 m | Verulam |

* Y = yes; N = no; I = intermittent

| Site No. | Quarry Name | Operator or Owner | MNR Lic | UTM | Coords | Township | Conc | Lot | MNR District | Active (*) | Thick-ness | Geological Formation(s) (Members) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NP-156 | Lennox G.S. Qy | Ontario Hydro | NO | 18T | 350900E 4890050N | S Fredericks-burgh | I | 16 | Napanee | N | 2.0 m | Verulam |
| NP-157 | Hawley Qy | unknown | NO | 18T | 350900E 4896000N | S Fredericks-burgh | III | 24 | Napanee | N | 1.5 m | Bobcaygeon |
| NP-158 | Lawrence Qy | unknown | NO | 18T | 341950E 4881050N | Adolphustown | I | 17 | Napanee | N | 0.0 m | Verulam |
| NP-159 | Croydon Qy # 1 | unknown | NO | 18T | 341800E 4921500N | Camden East | VIII | 14 | Napanee | N | 1.0 m | Gull River |
| NP-160 | Croydon Qy # 2 | unknown | NO | 18T | 343700E 4919200N | Camden East | VII | 15–16 | Napanee | N | unknown | Gull River |
| NP-161 | Centreville Qy # 1 | unknown | NO | 18T | 345550E 4917650N | Camden East | VI | 19 | Napanee | N | 4.0 m | Gull River |
| NP-162 | Enterprise Qy | unknown | NO | 18T | 351150E 4922800N | Camden East | V | 36 | Napanee | N | 2.8 m | Gull River |
| NP-163 | Moscow Qy # 1 | unknown | NO | 18T | 353900E 4923955N | Camden East | VI | 42 | Napanee | N | 0.0 m | Gull River |
| NP-164 | Moscow Qy # 2 | unknown | NO | 18T | 354800E 4922700N | Camden East | VI | 42 | Napanee | N | 2.0 m | Gull River |
| NP-165 | Centreville Qy # 2 | unknown | NO | 18T | 349000E 4917250N | Camden East | V | 24 | Napanee | N | 3.0 m | Gull River |
| NP-166 | Centreville Qy # 3 | unknown | NO | 18T | 349550E 4916900N | Camden East | V | 25 | Napanee | N | 2.0 m | Gull River |
| NP-167 | Milsap Qy | unknown | NO | 18T | 350950E 4915300N | Camden East | IV | 25 | Napanee | N | 3.9 m | Gull River |
| NP-168 | Wesley Qy | unknown | NO | 18T | 345700E 4911700N | Camden East | IV | 9 | Napanee | N | 0.0 m | Gull River |
| NP-169 | Strathcona Qy | Pearson & R. Sheltor | NO | 18T | 348250E 4907900N | Camden East | I | 11 | Napanee | N | unknown | Gull River |
| NP-170 | Strathcona Qy | Napanee Cement Co. | NO | 18T | 348250E 4907900N | Camden East | I | 10 | Napanee |  | unknown | Gull River |
| NP-171 | Strathcona Qy # 3 | unknown | NO | 18T | 349850E 4908200N | Camden East | I | 14 | Napanee | N | 3.0 m | Gull River |
| NP-172 | Newburgh Qy # 1 | unknown | NO | 18T | 349300E 4910900N | Camden East | II | 16 | Napanee | N | unknown | Gull River |
| NP-173 | Newburgh Qy # 2 | unknown | NO | 18T | 350650E 4909750N | Camden East | II | 17 | Napanee | N | unknown | Gull River |
| NP-174 | Newburgh Qy | unknown | NO | 18T | 350800E 4908850N | Camden East | I | 17 | Napanee | I | 4.5 m | Gull River |
| NP-175 | Camden E Qy # 1 | unknown | NO | 18T | 354050E 4910550N | Camden East | I | 26 | Napanee | N | 0.0 m | Gull River |
| NP-176 | Camden E Qy # 2 | unknown | NO | 18T | 355800E 4910600N | Camden East | I | 30 | Napanee | N | 2.0 m | Gull River |
| NP-177 | Camden E Qy # 3 | unknown | NO | 18T | 357050E 4912000N | Camden East | I | 35 | Napanee | N | 1.0 m | Gull River |
| NP-178 | Yarker Qy # 1 | unknown | NO | 18T | 358650E 4915400N | Camden East | II | 43 | Napanee | N | 0.0 m | Gull River |
| NP-179 | Yarker Qy # 2 | unknown | NO | 18T | 359050E 4913900N | Camden East | I | 41 | Napanee | N | 1.0 m | Gull River |
| NP-180 | Yarker Qy # 3 | unknown | NO | 18T | 359700E 4914700N | Camden East | I | 44 | Napanee | N | 1.0 m | Gull River |
| NP-181 | Camden E Qy # 4 | unknown | NO | 18T | 355000E 4909000N | Ernestown | VII | 20 | Napanee | N | 2.0 m | Gull River |
| NP-182 | Camden E Qy # 5 | unknown | NO | 18T | 355250E 4908700N | Ernestown | VII | 21 | Napanee | N | 0.0 m | Gull River |
| NP-183 | Camden E Qy # 6 | unknown | NO | 18T | 355800E 4906800N | Ernestown | VI | 20 | Napanee | N | 1.0 m | Gull River |
| NP-184 | Switzerville Qy | Carter Constr. Co. | NO | 18T | 353000E 4904400N | Ernestown | VI | 10 | Napanee | N | 1.0 m | Gull River |
| NP-185 | Camden E Qy # 7 | unknown | NO | 18T | 355000E 4904250N | Ernestown | VI | 15 | Napanee | N | 4.0 m | Gull River |
| NP-186 | Camden E Qy # 8 | unknown | NO | 18T | 356500E 4906250N | Ernestown | VI | 21 | Napanee | N | 1.0 m | Gull River |
| NP-187 | Wilton Qy # 2 | unknown | NO | 18T | 360500E 4910500N | Ernestown | VII | 35 | Napanee | N | unknown | Gull River |
| NP-188 | Wilton Qy # 3 | unknown | NO | 18T | 362700E 4910900N | Ernestown | VII | 40 | Napanee | N | 1.0 m | Gull River |
| NP-189 | Wilton Qy # 4 | unknown | NO | 18T | 362100E 4908300N | Ernestown | VI | 36 | Napanee | N | 1.5 m | Gull River |
| NP-190 | Violet Qy # 1 | unknown | NO | 18T | 352100E 4902600N | Ernestown | V | 7 | Napanee | N | 1.0 m | Gull River |
| NP-191 | Violet Qy # 2 | unknown | NO | 18T | 355500E 4903100N | Ernestown | V | 15 | Napanee | N | 2.0 m | Gull River |
| NP-192 | Hwy 133–401 Interchange | unknown | NO | 18T | 357600E 4903900N | Ernestown | V | 20 | Napanee | N | 2.0 m | Gull River |
| NP-193 | Potter (Odessa) Qy | unknown | NO | 18T | 363000E 4903600N | Ernestown | IV | 31–32 | Napanee | N | 2.0 m | Gull River |
| NP-194 | Odessa Qy | unknown | NO | 18T | 364050E 4901900N | Ernestown | III | 33 | Napanee | N | 2.0 m | Gull River |
| NP-195 | Bath Qy # 1 | unknown | NO | 18T | 354750E 4900000N | Ernestown | IV | 7 | Napanee | N | 0.0 m | Gull River |
| NP-196 | Napanee Qy # 11 | unknown | NO | 18T | 352250E 4898800N | Ernestown | IV | 3 | Napanee | N | unknown | Gull River |
| NP-197 | Bath Qy # 2 | unknown | NO | 18T | 355150E 4899400N | Ernestown | IV | 10 | Napanee | N | 1.0 m | Bobcaygeon |
| NP-198 | Millhaven Qy # 1 | unknown | NO | 18T | 358900E 4900450N | Ernestown | III | 20 | Napanee | N | 2.5 m | Bobcaygeon |
| NP-199 | Asseltine Qy | unknown | NO | 18T | 361800E 4900500N | Ernestown | III | 26 | Napanee | N | 2.0 m | Gull River |
| NP-200 | Amherstview Qy # 3 | unknown | NO | 18T | 365600E 4899000N | Ernestown | I | 34 | Napanee | N | unknown | Gull River |
| NP-201 | Bath Qy # 3 | unknown | NO | 18T | 356400E 4895450N | Ernestown | II | 9 | Napanee | N | 7.8 m | Bobcaygeon |
| NP-202 | Bath Qy # 4 | unknown | NO | 18T | 356700E 4895800N | Ernestown | II | 10 | Napanee | N | 3.0 m | Bobcaygeon |
| NP-203 | Bath Qy # 5 | unknown | NO | 18T | 356950E 4892500N | Ernestown | I | 7 | Napanee | N | 5.0 m | Verulam |
| NP-204 | Millhaven Qy # 2 | unknown | NO | 18T | 360800E 4894650N | Ernestown | I | 18 | Napanee | N | 6.0 m | Gull River |
| NP-205 | Amherstview Qy # 1 | unknown | NO | 18T | 362000E 4898000N | Ernestown | I | 22 | Napanee | N | 1.0 m | Gull River |
| NP-206 | Amherstview Qy # 2 | unknown | NO | 18T | 365000E 4897250N | Ernestown | I | 30 | Napanee | N | 5.0 m | Gull River |
| NP-207 | Amherstview Qy # 4 | unknown | NO | 18T | 369800E 4897700N | Ernestown | I | 42 | Napanee | N | 0.0 m | Gull River |
| NP-208 | Bellrock Qy | unknown | NO | 18T | 359750E 4923850N | Portland | IX | 19 | Napanee | N | 2.0 m | Gull River |
| NP-209 | Routley Qy | unknown | NO | 18T | 364750E 4923000N | Portland | VIII | 10–11 | Napanee | N | 4.5 m | Gull River |
| NP-210 | Leonard Qy | unknown | NO | 18T | 366700E 4923150n | Portland | VIII | 7–8 | Napanee | N | 5.2 m | Gull River |
| NP-211 | Knowlton Lake Qy | unknown | NO | 18T | 370100E 4922300N | Portland | VIII | 2 | Napanee | N | unknown | Gull River |

* Y = yes; N = no; I = intermittent

| Site No. | Quarry Name | Operator or Owner | MNR Lic | UTM | Coords | Township | Conc | Lot | MNR District | Active (*) | Thick-ness | Geological Formation(s) (Members) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NP-212 | Petworth Qy | unknown | NO | 18T | 361200E 4920050N | Portland | VI | 16 | Napanee | N | 4.0 m | Gull River |
| NP-213 | Shellington Qy | unknown | NO | 18T | 365800E 4920700N | Portland | VI-VII | 8-9 | Napanee | N | 3.5 m | Gull River |
| NP-214 | Wolfe's Swamp Qy | unknown | NO | 18T | 364700E 4917850N | Portland | V | 11 | Napanee | N | 3.0 m | Gull River |
| NP-215 | Sydenham Qy # 2 | unknown | NO | 18T | 370900E 4918500N | Portland | V | 1 | Napanee | N | 2.0 m | Gull River |
| NP-216 | Groenewegen Qy | unknown | NO | 18T | 366300E 4916000N | Portland | III | 8 | Napanee | N | 5.0 m | Gull River |
| NP-217 | Star Corners Qy # 1 | unknown | NO | 18T | 364350E 4914750N | Portland | II | 2 | Napanee | N | unknown | Gull River |
| NP-218 | Star Corners Qy # 2 | unknown | NO | 18T | 364600E 4913700N | Portland | II | 11 | Napanee | N | unknown | Gull River |
| NP-219 | Henderson (Murvale) Qu. | unknown | NO | 18T | 367450E 4913300N | Portland | I | 6-7 | Napanee | N | 13.0 m | Gull River |
| NP-220 | Sydenham Qy # 1 | unknown | NO | 18T | 372000E 4918600N | Loughborough | V | 2 | Napanee | N | unknown | Gull River |
| NP-221 | Rosedale Qy | unknown | NO | 18T | 374600E 4921400N | Loughborough | VII | 7 | Napanee | N | 9.1 m | Gull River |
| NP-222 | Sydenham Qy # 3 | unknown | NO | 18T | 373400E 4918150N | Loughborough | IV | 5 | Napanee | N | 2.0 m | Gull River |
| NP-223 | Railton Qy | unknown | NO | 18T | 373050E 4915300N | Loughborough | III | 4 | Napanee | N | unknown | Gull River |
| NP-224 | Inverary Qy # 2 | unknown | NO | 18T | 382600E 4918000N | Storrington | IV | 20 | Napanee | N | 5.0 m | Gull River |
| NP-225 | Inverary Qy # 1 | unknown | NO | 18T | 383350E 4915400N | Storrington | II | 21 | Napanee | N | 4.0 m | Gull River |
| NP-226 | Latimer Qy # 1 | unknown | NO | 18T | 379300E 4914700N | Storrington | II | 14 | Napanee | N | unknown | Gull River |
| NP-227 | Latimer Qy # 2 | unknown | NO | 18T | 338450E 4912050N | Storrington | VII W | 20 | Napanee | N | 1.0 m | Gull River |
| NP-228 | Shannons Corners Qy 1 | unknown | NO | 18T | 380500E 4911900N | Storrington | VII W | 26 | Napanee | N | unknown | Gull River |
| NP-229 | Collins Lake Qy | unknown | NO | 18T | 383000E 4912500N | Storrington | VII W | 32 | Napanee | N | 5.0 m | Gull River |
| NP-230 | Sunbury Qy | unknown | NO | 18T | 386500E 4915900N | Storrington | VII | 1 | Napanee | N | 3.0 m | Gull River |
| NP-231 | Sharpton Qy # 1 | unknown | NO | 18T | 367000E 4910100N | Kingston | VI W Division | 11 | Napanee | N | 1.0 m | Gull River |
| NP-232 | Sharpton Qy # 2 | unknown | NO | 18T | 366650E 4909600N | Kingston | VI W Division | 12 | Napanee | N | 2.0 m | Gull River |
| NP-233 | Sharpton Qy # 3 | unknown | NO | 18T | 366550E 4909450N | Kingston | VI W Division | 12 | Napanee | N | 0.0 m | Gull River |
| NP-234 | Glenvale Qy # 1 | unknown | NO | 18T | 370200E 4911000N | Kingston | VIII W Division | 3 | Napanee | N | 1.5 m | Gull River |
| NP-235 | Glenvale Qy # 2 | unknown | NO | 18T | 370250E 4910600N | Kingston | VIII W Division | 3 | Napanee | N | 1.5 m | Gull River |
| NP-236 | Glenvale Qy # 3 | unknown | NO | 18T | 370050E 4908000N | Kingston | V | 2 | Napanee | N | 2.0 m | Gull River |
| NP-237 | Westbrook Qy # 4 | unknown | NO | 18T | 368100E 4905500N | Kingston | IV W Division | 8 | Napanee | N | 3.0 m | Gull River |
| NP-238 | Westbrook Qy | Kingston Aggregates | NO | 18T | 369900E 4905250N | Kingston | IV W Division | 4-5 | Napanee | N | 1.0 m | Gull River |
| NP-239 | Elginburg Qy # 2 | unknown | NO | 18T | 377250E 4909500N | Kingston | VI | 17 | Napanee | N | 2.0 m | Gull River |
| NP-240 | Shannons Corners Qy 2 | unknown | NO | 18T | 380000E 4909500N | Kingston | VI | 24 | Napanee | N | 0.0 m | Gull River |
| NP-241 | Elginburg Qy # 3 | unknown | NO | 18T | 375500E 4907200N | Kingston | V | 13 | Napanee | N | unknown | Gull River |
| NP-242 | Shannons Corners Qy 3 | unknown | NO | 18T | 379250E 4907500N | Kingston | V | 22 | Napanee | N | 2.0 m | Gull River |
| NP-243 | Silvers Corners Qy | unknown | NO | 18T | 377850E 4906000N | Kingston | IV | 20 | Napanee | N | 0.0 m | Gull River |
| NP-244 | Glenburnie Qy | unknown | NO | 18T | 382500E 4908750N | Kingston | VI | 30 | Napanee | N | unknown | Gull River |
| NP-245 | Fairmount Qy # 1 | unknown | NO | 18T | 383600E 4909050N | Kingston | VI | 34 | Napanee | N | unknown | Gull River |
| NP-246 | Fairmount Qy # 2 | unknown | NO | 18T | 383400E 4908750N | Kingston | VI | 33 | Napanee | N | 2.0 m | Gull River |
| NP-247 | Fairmount Qy # 3 | unknown | NO | 18T | 383600E 4908500N | Kingston | VI | 33 | Napanee | N | 0.0 m | Gull River |
| NP-248 | Fairmount Qy # 4 | unknown | NO | 18T | 382400E 4907300N | Kingston | V | 32 | Napanee | N | unknown | Gull River |
| NP-249 | Maple Lawn Qy | unknown | NO | 18T | 383750E 4905900N | Kingston | IV | 32 | Napanee | N | 2.0 m | Gull River |
| NP-250 | Aylesworth Qy # 1 | unknown | NO | 18T | 375500E 4904550N | Kingston | IV | 19 | Napanee | N | 2.0 m | Gull River |
| NP-251 | Aylesworth Qy # 2 | unknown | NO | 18T | 375800E 4904200N | Kingston | IV | 14 | Napanee | N | 1.0 m | Gull River |
| NP-252 | Aylesworth Qy # 3 | unknown | NO | 18T | 377200E 4904700N | Kingston | IV | 18 | Napanee | N | 0.0 m | Gull River |
| NP-253 | Aylesworth Qy # 4 | unknown | NO | 18T | 378100E 4904100N | Kingston | IV | 20 | Napanee | N | 4.0 m | Gull River |
| NP-254 | Kingston Mills Qy | unknown | NO | 18T | 282950E 4904300N | Kingston | IV | 33 | Napanee | N | 9.3 m | Gull River |
| NP-256 | Westbrook Qy # 5 | unknown | NO | 18T | 368400E 4904500N | Kingston | IV | 8 | Napanee | N | 1.0 m | Gull River |
| NP-257 | Westbrook Qy # 6 | unknown | NO | 18T | 368600E 4903750N | Kingston | IV W Division | 7 | Napanee | N | unknown | Gull River |
| NP-258 | Westbrook Qy # 7 | unknown | NO | 18T | 367750E 4903200N | Kingston | III W Division | 9 | Napanee | N | 2.0 m | Gull River |
| NP-259 | Collins Bay Qy # 3 | unknown | NO | 18T | 370050E 4901600N | Kingston | III W Division | 3 | Napanee | N | 2.0 m | Gull River |
| NP-260 | Collins Bay Qy # 4 | unknown | NO | 18T | 371250E 4900600N | Kingston | II | 1 | Napanee | N | 0.0 m | Gull River |
| NP-261 | Collins Bay Qy | W.B. Bennett Ltd. | NO | 18T | 372950E 4899000N | Kingston | I | 5 | Napanee | N | 12.0 m | Gull River, Bobcaygeon |
| NP-262 | Lemoine's Point Qy | unknown | NO | 18T | 372000E 4896800N | Kingston | I | 3 | Napanee | N | 8.0 m | Gull River |
| NP-263 | Collins Bay Pen. Qy 1 | Collins Bay Pen. | NO | 18T | 375950E 4897200N | Kingston | I | – | Napanee | N | 1.0 m | Gull River |
| NP-264 | Collins Bay Pen. Qy 2 | Collins Bay Pen. | NO | 18T | 375250E 4898900N | Kingston | I | 10 | Napanee | N | 8.4 m | Gull River |
| NP-265 | Turner Drive Qy | unknown | NO | 18T | 375800E 4899650N | Kingston | II | – | Napanee | N | 3.5 m | Gull River |
| NP-266 | Kirkpatrick Qy | unknown | NO | 18T | 377500E 4899600N | Kingston | II | 16 | Napanee | N | 3.0 m | Gull River |
| NP-267 | Valleyview Qy | unknown | NO | 18T | 377950E 4900250N | Kingston | II | 18 | Napanee | N | 2.0 m | Gull River |
| NP-268 | Kingston Qy # 5 | unknown | NO | 18T | 378000E 4900600N | Kingston | II | 18 | Napanee | N | 0.0 m | Gull River |
| NP-269 | Kingston Qy # 6 | unknown | NO | 18T | 378250E 4901250N | Kingston | II | 18 | Napanee | N | 0.0 m | Gull River |

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| Site No. | Quarry Name | Operator or Owner | MNR Lic | UTM | Coords | Township | Conc | Lot | MNR District | Active (*) | Thick- ness | Geological Formation(s) (Members) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NP-270 | Kingston Qy # 7 | unknown | NO | 18T | 378600E 4901200N | Kingston | II | 19 | Napanee | N | 0.0 m | Gull River |
| NP-271 | Kingston Qy # 8 | unknown | NO | 18T | 378350E 4901950N | Kingston | III | 20 | Napanee | N | 2.0 m | Gull River |
| NP-272 | Kingston Qy | Frontenac Quarries | NO | 18T | 380800E 4902100N | Kingston | W. of Cataraqui R. | 1–5 | Napanee | N | 17.0 m | Gull River |
| NP-273 | Rideau Heights Qy | unknown | NO | 18T | 381800E 4901700N | Kingston | II | 28 | Napanee | N | 2.0 m | Gull River |
| NP-274 | Kingston Qy # 9 | unknown | NO | 18T | 379700E 4901500N | Kingston | III | 23 | Napanee | N | 0.0 m | Gull River |
| NP-275 | Kingscourt Qy | unknown | NO | 18T | 380100E 4901500N | Kingston | II | 22 | Napanee | N | 4.0 m | Gull River |
| NP-276 | Weham Qy | J. Weham | NO | 18T | 380400E 4900250N | Kingston | I | 25 | Napanee | N | 10.0 m | Gull River |
| NP-277 | Roddy Qy | J.M. Roddy | NO | 18T | 380600E 4900200N | Kingston | I | 25 | Napanee | N | 5.0 m | Gull River |
| NP-278 | Montreal Street Qy #1 | unknown | NO | 18T | 381050E 4899950N | Kingston | I | 26 | Napanee | N | 7.0 m | Gull River |
| NP-279 | Montreal Street Qy #2 | unknown | NO | 18T | 481200E 4899900N | Kingston | I | 26 | Napanee | N | 3.0 m | Gull River |
| NP-280 | Montreal Street Qy #3 | unknown | NO | 18T | 381250E 4899100N | Kingston | I | 26 | Napanee | N | 3.0 m | Gull River |
| NP-281 | Montreal Street Qy #4 | unknown | NO | 18T | 381250E 4898900N | Kingston | II | 26 | Napanee | N | 3.1 m | Gull River |
| NP-282 | Portsmouth Qy # 1 | unknown | NO | 18T | 278950E 4898300N | Kingston | I | – | Napanee | N | 0.0 m | Gull River |
| NP-283 | Portsmouth Qy # 2 | unknown | NO | 18T | 379200E 4897900N | Kingston | I | – | Napanee | N | 0.0 m | Gull River |
| NP-284 | Portsmouth Qy # 3 | unknown | NO | 18T | 378950E 4898000N | Kingston | I | – | Napanee | N | 0.0 m | Gull River |
| NP-285 | Portsmouth Qy # 4 | unknown | NO | 18T | 378200E 4897800N | Kingston | I | – | Napanee | N | 0.0 m | Gull River |
| NP-286 | Portsmouth Qy # 5 | unknown | NO | 18T | 378600E 4897500N | Kingston | I | 19 | Napanee | N | 5.0 m | Gull River |
| NP-287 | Portsmouth Qy # 6 | unknown | NO | 18T | 379000E 4897800N | Kingston | I | – | Napanee | N | 0.0 m | Gull River |
| NP-288 | Pine Hill Qy # 1 | unknown | NO | 18T | 391100E 4910150N | Pittsburgh | IV | 12 | Napanee | N | 2.0 m | Gull River |
| NP-289 | Joyceville Pen. Qy | Joyceville Penitentiary | NO | 18T | 392500E 4911750N | Pittsburgh | V | 16 | Napanee | N | 4.0 m | Gull River |
| NP-290 | Pine Hill Qy # 2 | unknown | NO | 18T | 393150E 4910400N | Pittsburgh | IV | 17 | Napanee | N | 6.0 m | Gull River |
| NP-291 | Rideau Sta Qy | unknown | NO | 18T | 386000E 4905050N | Pittsburgh | E of Cataraqui R. | D | Napanee | N | 8.0 m | Gull River |
| NP-292 | Joyceville Road Qy | unknown | NO | 18T | 393750E 4907000N | Pittsburgh | III | 18 | Napanee | N | 5.0 m | Gull River |
| NP-293 | Middle Road Qy | unknown | NO | 18T | 393650E 4906500N | Pittsburgh | III | 18 | Napanee | N | 6.3 m | Gull River |
| NP-294 | Bateau Channel Qy # 2 | unknown | NO | 18T | 397450E 4906350N | Pittsburgh | II | 28 | Napanee | N | 1.2 m | Gull River |
| NP-295 | Bateau Channel Qy # 1 | unknown | NO | 18T | 397250E 4906000N | Pittsburgh | II | 27 | Napanee | N | 2.1 m | Gull River |
| NP-296 | Pitts Ferry Qy | unknown | NO | 18T | 393750E 4904400N | Pittsburgh | I | 18 | Napanee | N | 3.5 m | Gull River |
| NP-297 | Abbey Dawn Qy | unknown | NO | 18T | 388400E 4901800N | Pittsburgh | I | 4 | Napanee | N | 4.0 m | Gull River |
| NP-298 | MacLean Qy | unknown | NO | 18T | 384650E 4901650N | Pittsburgh | E of Catarqui R. | 11 | Napanee | N | unknown | Gull River |
| NP-299 | Barriefield Qy | unknown | NO | 18T | 383100E 4899350N | Pittsburgh | E of Cataraqui R. | – | Napanee | N | 3.0 m | Gull River |
| NP-300 | Howe Island Qy # 2 | unknown | NO | 18T | 394200E 4902600N | Howe Island | N Range | 5 | Napanee | N | 4.1 m | Gull River |
| NP-301 | Howe Island Qy # 3 | unknown | NO | 18T | 395000E 4900150N | Howe Island | S Range | 5 | Napanee | N | 1.2 m | Gull River |
| NP-302 | Howe Island Qy # 4 | unknown | NO | 18T | 395600E 4900200N | Howe Island | S Range | 6 | Napanee | N | 1.0 m | Gull River |
| NP-303 | Howe Island Qy # 5 | unknown | NO | 18T | 398700E 4901700N | Howe Island | S Range | 13 | Napanee | N | 2.0 m | Gull River |
| NP-304 | Howe Island Qy # 6 | unknown | NO | 18T | 400700E 4903700N | Howe Island | S Range | 19 | Napanee | N | unknown | Gull River |
| NP-305 | Howe Island Qy # 7 | unknown | NO | 18T | 401900E 4903700N | Howe Island | S Range | 21 | Napanee | N | 6.0 m | Gull River |
| NP-306 | Ramsay Qy | unknown | NO | 18T | 348500E 4909000N | Camden East | II | 12 | Napanee | N | unknown | Gull River |
| NP-307 | Consecon Qy # 3 | unknown | NO | 18T | 298050E 4873600N | Hillier | IV | 107 | Napanee | N | 3.0 m | Lindsay |
| NP-308 | Boat Channel Qy | unknown | NO | 18T | 380750E 4892250N | Wolfe Island | Registered Plan 73 | 23 | Napanee | N | 0.0 m | Gull River |
| NP-309 | Lamberts Hill Qy | unknown | NO | 18T | 383000E 4893700N | Wolfe Island | Registered Plan 73 | 11 | Napanee | N | 2.0 m | Gull River |
| NP-310 | White Qy | Ken White | NO | 18T | 384400E 4893400N | Wolfe Island | Registered Plan 73 | 6–8 | Napanee | N | unknown | Gull River |
| NP-311 | Marysville Qy # 3 | unknown | NO | 18T | 384950E 4893400N | Wolfe Island | Registered Plan 73 | 2 | Napanee | N | 1.0 m | Gull River |
| NP-312 | Hulton Qy | E.J. Hulton | NO | 18T | 386500E 4892800N | Wolfe Island | VIII N | 2 | Napanee | N | 0.5 m | Bobcaygeon |
| NP-313 | Marysville Qy # 4 | unknown | NO | 18T | 385550E 4894050N | Wolfe Island | VIII N | 3 | Napanee | N | 3.0 m | Bobcaygeon |
| NP-314 | Wolfe Island Landfill | unknown | NO | 18T | 386000E 4894500N | Wolfe Island | VIII N | 3 | Napanee | N | 4.0 m | Gull River |
| NP-315 | Fawcett Qy | R.F. Fawcett | NO | 18T | 389800E 4897000N | Wolfe Island | XI N | 4 | Napanee | N | unknown | Gull River |
| NP-316 | Scotch Settlement Qy | unknown | NO | 18T | 392950E 4895600N | Wolfe Island | XIII S | 2 | Napanee | N | 2.3 m | Gull River |
| NP-317 | Lewis Bay Qy | unknown | NO | 18T | 398900E 4896450N | Wolfe Island | XVII | 6 | Napanee | N | 2.6 m | Gull River |
| NP-318 | The Ridge Qy | unknown | NO | 18T | 387400E 4888950N | Wolfe Island | VII | 6 | Napanee | N | 2.0 m | Verulam |
| O-01 | Adair Marble –Main Qy | Arriscraft Corp. | YES | 17T | 487250E 4969300N | Albemarle | VIII | 7–8, | Owen Snd | Y | 7.0 m | Amabel (Wiarton/ Colpoy Bay) |
| O-02 | Moor Developments Qy | Moor Developments Inc. | YES | 17T | 479200E 4968300N | Albemarle | I EBR | 3 | Owen Snd | Y | 5.0 m | Amabel (Eramosa) |

* Y = yes; N = no; I = intermittent

| Site No. | Quarry Name | Operator or Owner | MNR Lic | UTM | Coords | Township | Conc | Lot | MNR District | Active (*) | Thick-ness | Geological Formation(s) (Members) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| O-03 | Ross Qy | Donald Ross | YES | 17T | 484750E 4956550N | Amabel | XXV | 10-11 | Owen Snd | Y | 4.0 m | Amabel (Eramosa) |
| O-04 | Cook Qy | J.S. Cook | NO | 17T | 485900E 4955350N | Amabel | XXIV | 7-8 | Owen Snd | N | 4.6 m | Amabel (Eramosa), Guelph |
| O-05 | Wiarton Qy | Owen Sound Ledgerock | YES | 17T | 484800E 4955200N | Amabel | XXIII | 10-11 | Owen Snd | Y | 8.3 m | Amabel (Eramosa) |
| O-06 | Ebel Qy | Griff Ebel | YES | 17T | 486300E 4955250N | Amabel | XXIII | 6-8 | Owen Snd | Y | 12.0 m | Amabel (Eramosa) |
| O-07 | McCartney Qy | Cliff McCartney | YES | 17T | 492150E 4949650N | Keppel | XVIII | 7-9 | Owen Snd | Y | 3.4 m | Amabel (Eramosa) |
| O-08 | Cruickshank (Keppel) Qy | Owen Sound Ledgerock | YES | 17T | 496450E 4937200N | Keppel | IV | 17 | Owen Snd | Y | 1.9 m | Amabel (Eramosa) |
| O-09 | Tolhurst Qy | E.C. King Contracting | YES | 17T | 505500E 4949200N | Sarawak | II | 37 | Owen Snd | I | 6.0 m | Manitoulin |
| O-10 | Sydenham Qy | E.C. King Contracting | YES | 17T | 511100E 4934750N | Sydenham | I-II S.C.R. | 23-25 | Owen Snd | Y | 15.2 m | Amabel (Wiarton/ Colpoy Bay) |
| O-11 | Davison Farm Qy | H. Sutherland | YES | 17T | 533500E 4932500N | St. Vincent | V | 5 | Owen Snd | Y | 3.0 m | Manitoulin |
| O-12 | Lions Head Qy | unknown | NO | 17T | 479600E 4982000N | Eastnor | V or VI | 29 or 30 | Owen Snd | N | 7.0 m | Amabel |
| O-13 | Hope Bay | unknown | NO | 17T | 486600E 4971650N | Albemarle | VIII | 2 | Owen Snd | N | 2.0 m | Amabel (Wiarton/ Colpoy Bay) |
| O-14 | Arriscraft - N Qy | Arriscraft Corp. | YES | 17T | 486750E 4970800N | Albemarle | VIII | 4 | Owen Snd | N | 5.0 m | Amabel (Wiarton/ Colpoy Bay) |
| O-15 | Wiarton N Qy | Owen Sound Ledgerock . | YES | 17T | 485350E 4955600N | Amabel | XXIV | 9 | Owen Snd | I | 1.0 m | Amabel (Eramosa), Guelph |
| O-16 | Wiarton Qy | Bruce Peninsula St. Qys. | NO | 17T | 487200E 4955350N | Amabel | XXIV | 7 | Owen Snd | N | 2.1 m | Amabel (Eramosa), Guelph |
| O-17 | Boat Lake Qy | L. Ross | NO | 17T | 483500E 4953500N | Amabel | XXII | 14 | Owen Snd | N | 1.0 m | Guelph |
| O-18 | Boat Lake Qy # 2 | unknown | NO | 17T | 484300E 4953300N | Amabel | XII | 12 | Owen Snd | N | unknown | Guelph |
| O-19 | Charles Lake Qy | unknown | NO | 17T | 497900E 4956700N | Keppel | XXIV | 23 | Owen Snd | N | 2.0 m | Amabel |
| O-20 | Kemble Qy | unknown | NO | 17T | 507000E 4952300N | Keppel | Georgian Range | 18 | Owen Snd | N | unknown | Manitoulin |
| O-21 | Shallow Lake Qy | unknown | NO | 17T | 492550E 4940000N | Keppel | VII | 8 | Owen Snd | N | 5.0 m | Amabel |
| O-22 | McDonald Qy | unknown | NO | 17T | 487320E 4934000N | Amabel | II | 7 | Owen Snd | N | 1.0 m | Guelph |
| O-23 | Alvanley Qy | unknown | NO | 17T | 490200E 4932000N | Derby | Indian Strip | 20 | Owen Snd | N | 3.0 m | Guelph |
| O-24 | Owen Sound W Quarries | various | NO | 17T | 501900E 4935600N | Sarawak | II | 3 | Owen Snd | N | 1.0 m | Amabel (Wiarton/ Colpoy Bay) |
| O-25 | Chalmers Qy | D. Chalmers | NO | 17T | 501500E 4934300N | Derby | Indian Strip | 6 or 7 | Owen Snd | N | 5.0 m | Amabel |
| O-26 | Brown's Lime Works | Brown's Lime Works | NO | 17T | 505800E 4932750N | Derby | I | 14 or 15 | Owen Snd | N | 5.0 m | Amabel |
| O-27 | Owen Sound E Quarries | various | NO | 17T | 506000E 4935600N | Sydenham | City of Owen Sound | - | Owen Snd | N | 6.5 m | Manitoulin |
| O-28 | Bothwell Corners Qy | unknown | NO | 17T | 510300E 4936000N | Sydenham | I NCR or I SCR | 25 or 26 | Owen Snd | N | 8.0 m | Amabel |
| O-29 | Cape Chin Qy | unknown | NO | 17T | 474300E 4891300N | Lindsay | V | 12 | Owen Snd | N | 4.0 m | Guelph |
| O-30 | Inverhuron Qy | unknown | NO | 17T | 452400E 4903200N | Kincardine | A | 67 | Owen Snd | N | unknown | Lucas |
| O-31 | Kincardine Qy | Ministry of Transport | NO | 17T | 455250E 4889600N | Kincardine | I SDR | 11 | Owen Snd | N | 1.0 m | Lucas |
| O-32 | Penetangore Qy | A.W. Holland & J. Keys | NO | 17T | 455100E 4888700N | Kincardine | III S | 6-9 | Owen Snd | N | 15.0 m | Lucas |
| O-33 | Formosa (Hydro) Qy | Hanover Portland Cement | NO | 17T | 482700E 4883200N | Brant | III S of Durham Rd | B | Owen Snd | N | 9.0 m | Amherstburg ("Formosa Reef") |
| O-34 | Cargill Qy | R. Dobson | NO | 17T | 482900E 4892800N | Brant | VII | 2 | Owen Snd | N | 13.0 m | Bertie |
| O-35 | Walkerton Qy | unknown | NO | 17T | 489000E 4885500N | Brant | II S of Durham Road | 29 | Owen Snd | N | 2.0 m | Bertie |
| O-36 | Craigleith Qy | unknown | NO | 17T | 551100E 4931500N | Collingwood | IV | 25 | Owen Snd | N | 4.2 m | Lindsay (Collingwood) |
| PE-01 | Fourth Chute Qy | Township of Bromley | NO | 18T | 342900E 5040200N | Grattan | XV | 8 | Pembroke | Y | 8.5 m | Bobcaygeon |
| PE-02 | Braeside Qy | Smiths Constr. Co. Ltd. | NO | 18T | 387050E 5035850N | McNab | A | 16 | Pembroke | Y | 8.1 m | Bobcaygeon |
| PE-03 | Clay Bank Qy | H & H Aggregates | NO | 18T | 390400E 5026700N | McNab | IX | 1 | Pembroke | Y | 17.4 m | Bobcaygeon |
| PE-07 | Pembroke Qy | unknown | NO | 18T | 337000E 5074600N | Pembroke | I | 12 | Pembroke | N | 3.0 m | Gull River |
| PE-08 | Meath Qy | unknown | NO | 18T | 344900E 5065100N | Westmeath | I W of Muskrat Lk | 19 | Pembroke | N | 4.0 m | Gull River |
| PE-09 | Eganville Qy | unknown | NO | 18T | 341300E 5041800N | Grattan | XVII | 12 | Pembroke | N | 16.2 m | Bobcaygeon |
| S-01 | Pierce Qy | Chuck Mattice | NO | 17T | 571700E 4757350N | Walpole | XIV | 7 | Simcoe | N | 7.1 m | Bertie, Bois Blanc (Springvale) |
| S-02 | Port Dover Qy | Norfolk Quarries Co. | YES | 17T | 566600E 4739900N | Woodhouse | II | 13-14 | Simcoe | Y | 15.0 m | Dundee |
| S-03 | Bealton Qy | unknown | NO | 17T | 566000E 4758300N | Townsend | VI | 21 | Simcoe | N | unknown | Bois Blanc |
| S-04 | Villa Nova Qy | McLaren | NO | 17T | 564500E 4754900N | Townsend | VIII | 18 | Simcoe | N | 2.0 m | Bois Blanc |
| S-05 | Rockford Qy | unknown | NO | 17T | 568100E 4751500N | Townsend | XI | 22 | Simcoe | N | unknown | Onondaga |
| S-06 | Jarvis Qy | Ont. Land Corp. | NO | 17T | 569700E 4749000N | Townsend | XIII | 24 | Simcoe | N | 0.0 m | Bois Blanc, Onondaga |
| S-07 | Jarvis Qy #2 | Ministry of Transportation | NO | 17T | 567500E 4746200N | Townsend | XIV | 19 | Simcoe | N | 3.2 m | Dundee |
| S-08 | Varency Qy | unknown | NO | 17T | 568500E 4745000N | Woodhouse | V | 20 | Simcoe | N | unknown | Dundee |
| S-09 | Stelco (Nanticoke) Qy | Stelco | NO | 17T | 572900E 4739250N | Woodhouse | I | 24 | Simcoe | N | 15.0 m | Dundee |
| S-10 | Springvale Qy # 1 | unknown | NO | 17T | 567900E 4759050N | Walpole | XVI | 2 | Simcoe | N | unknown | Bertie |

* Y = yes; N = no; I = intermittent

| Site No. | Quarry Name | Operator or Owner | MNR Lic | UTM | Coords | Township | Conc | Lot | MNR District | Active (*) | Thick-ness | Geological Formation(s) (Members) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S-11 | Cayuga (Teitz) Qy | Cayuga Mat. & Constr. | NO | 17T | 568000E 4756800N | Walpole | XIV | 1 | Simcoe | N | 2.0 m | Onondaga |
| S-12 | Springvale (Winger) Qy | Standard Aggregates | NO | 17T | 571200E 4756650N | Walpole | XIV | 5–6 | Simcoe | N | 2.2 m | Bois Blanc (upper member) |
| S-13 | Gray (Springvale) Qy | unknown | NO | 17T | 571500E 4756400N | Walpole | XIII | 6 | Simcoe | N | unknown | Bois Blanc |
| S-14 | Springvale Qy # 2 | unknown | NO | 17T | 574000E 4757050N | Walpole | XIV | 10 | Simcoe | N | unknown | Bois Blanc, Onondaga |
| S-15 | Hagersville N Qy | Standard Aggregates | YES | 17T | 576000E 4757800N | Walpole | XIII | 13–14 | Simcoe | N | 6.3 m | Bois Blanc, Onondaga |
| S-16 | Hagersville Nwest Qy | Dufferin Aggregates | NO | 17T | 575400E 4756200N | Walpole | XIII | 12 | Simcoe | N | 3.9 m | Onondaga |
| S-17 | Hagersville E Qy | Dufferin Aggregates | NO | 17T | 576000E 4756450N | Walpole | XIII | 13 | Simcoe | N | 9.0 m | Bois Blanc, Onondaga |
| S-18 | Hagersville S Qy | Dufferin Aggregates | NO | 17T | 576000E 4755700N | Walpole | XII | 13 | Simcoe | N | 4.2 m | Onondaga |
| S-19 | Hagersville (SW) Qy | Dufferin Aggregates | YES | 17T | 575900E 4755200N | Walpole | XII | 12 | Simcoe | N | 0.0 m | Onondaga |
| S-20 | Sandusk Qy | unknown | NO | 17T | 579250E 4744400N | Walpole | IV | 13 | Simcoe | N | unknown | Dundee |
| S-21 | Nanticoke Qy | unknown | NO | 17T | 575700E 4741400N | Walpole | II | 6 | Simcoe | N | 3.1 m | Dundee |
| S-22 | Nanticoke Qy #2 | unknown | NO | 17T | 575500E 4739900N | Walpole | I | 5 | Simcoe | N | 1.8 m | Dundee |
| S-23 | Cheapside Qy | Haldimand-Norfolk R. M. | NO | 17T | 582500E 4744800N | Walpole | IV | 18 | Simcoe | N | 3.1 m | Dundee |
| S-24 | Cheapside Qy #2 | unknown | NO | 17T | 583000E 4744300N | Walpole | III | 19 | Simcoe | N | 1.5 m | Dundee |
| S-25 | Selkirk Qy | unknown | NO | 17T | 587100E 4746100N | Rainham | III | 2 | Simcoe | N | 4.4 m | Dundee |
| S-26 | Helkies Qy | Glen Chambers | NO | 17T | 587700E 4744200N | Rainham | II | 2 | Simcoe | N | 1.5 m | Onondaga (Moorehouse) |
| S-27 | Selkirk Qy #2 | unknown | NO | 17T | 587700E 4743500N | Rainham | II | 2 | Simcoe | N | unknown | Onondaga |
| S-28 | Selkirk Qy #1 | unknown | NO | 17T | 588000E 4743200N | Rainham | II | 2 | Simcoe | N | 5.0 m | Dundee |
| S-29 | Dogs Nest Qy | unknown | NO | 17T | 567500E 4740000N | Woodhouse | II | 15 | Simcoe | N | unknown | Dundee |
| TW-01 | Marmora Pit | Marmoraton Mining Co. | NO | 18T | 288750E 4928200N | Marmora | V | 4 | Tweed | N | 43.9 m | Shadow Lake, Gull River, Bobcaygeon |
| TW-02 | Jarvis Lake Qy | Stoklosar Marble Qys. | YES | 18T | 295850E 4934150N | Madoc | I | 11 | Tweed | Y | 4.5 m | Gull River |
| TW-03 | Madoc Marble Qy | Stoklosar Marble Qys. | YES | 18T | 299650E 4935125N | Madoc | IV | 10 | Tweed | Y | 5.5 m | Shadow Lake, Gull River |
| TW-04 | Crookston Qy | H.J. McFarland Constr. | YES | 18T | 304850E 4922550N | Huntingdon | IX | 10 | Tweed | Y | 7.5 m | Bobcaygeon |
| TW-20 | Cordova Mines Qy | unknown | NO | 18T | 281100E 4939300N | Marmora | III | 26 | Tweed | N | 2.5 m | Gull River |
| TW-21 | Marmora Qy | Bonter & American Lithography | NO | 18T | 284300E 4928750N | Marmora | III | 8 | Tweed | N | 1.0 m | Gull River |
| TW-22 | Crowe Lake Qy | American Lithography | NO | 18T | 285200E 4929000N | Marmora | III | 7 | Tweed | N | unknown | Gull River |
| TW-23 | Pearce Qy | Pearce | NO | 18T | 286000E 4929100N | Marmora | IV | 7 | Tweed | N | unknown | Gull River |
| TW-24 | Marmora Qy # 2 | unknown | NO | 18T | 287500E 4927000N | Marmora | IV | 3 | Tweed | N | 1.0 m | Bobcaygeon |
| TW-25 | Deloro Qy | abandoned | NO | 18T | 291400E 4932600N | Marmora | VIII | 10 | Tweed | N | 4.8 m | Gull River |
| TW-26 | Keller Bridge Qy | Stoklosar Marble Qys. | YES | 18T | 299050E 4942950N | Madoc | VI | 23 | Tweed | N | 5.5 m | Gull River |
| TW-27 | Eldorado Qy | unknown | NO | 18T | 300150E 4939050N | Madoc | V | 16 | Tweed | N | 6.3 m | Bobcaygeon |
| TW-28 | Madoc Qy # 1 | unknown | NO | 18T | 300700E 4934000N | Madoc | V | 8 | Tweed | N | 5.0 m | Gull River |
| TW-29 | Madoc Qy # 2 | unknown | NO | 18T | 305100E 4933950N | Madoc | VIII | 5 | Tweed | N | 2.0 m | Gull River |
| TW-30 | Quinmolac Qy | unknown | NO | 18T | 304400E 4926200N | Huntingdon | XII | 11 | Tweed | N | 5.0 m | Bobcaygeon |
| TW-31 | Crookston Qy # 2 | unknown | NO | 18T | 305000E 4922200N | Huntingdon | IX | 10 | Tweed | N | 8.1 m | Bobcaygeon |
| TW-32 | Crookston Qy # 3 | unknown | NO | 18T | 305300E 4921700N | Huntingdon | VIII | 11 | Tweed | N | 3.9 m | Bobcaygeon |
| TW-33 | Crookston Qy # 4 | unknown | NO | 18T | 306050E 4922300N | Huntingdon | IX | 12 | Tweed | N | unknown | Bobcaygeon |
| TW-34 | Tweed Qy | unknown | NO | 18T | 316300E 4928700N | Hungerford | XI | 12 | Tweed | N | 7.3 m | Bobcaygeon |
| TW-35 | Mellon Lake Qy | unknown | NO | 18T | 332500E 4934600N | Sheffield | III | 23 | Tweed | N | 2.0 m | Gull River |
| TW-36 | Eldorado Qy | Hastings Marble Products | NO | 18T | 299550E 4935000N | Madoc | IV | 9 | Tweed | N | 2.0 m | Gull River |
| W-01 | St. Marys Qy | St. Marys Cement Co. | YES | 17T | 487150E 4788075N | Blanshard | BFC & Thames River C | 14–16 & 25–26 | Wingham | Y | 18.2 m | Lucas, Dundee |
| W-02 | Formosa Qy | Town of Formosa | NO | 17T | 483000E 4878700N | Carrick | A | 53 | Wingham | N | 5.0 m | Amherstburg ("Formosa Reef") |
| W-03 | Teeswater (N) Qy | unknown | NO | 17T | 477000E 4871800N | Culross | VII | 15 | Wingham | N | 12.0 m | Amherstburg |
| W-04 | Teeswater Qy | Gypsum, Lime & Alabast. | NO | 17T | 477500E 4871000N | Culross | VI | 14 | Wingham | N | 15.0 m | Amherstburg |
| W-05 | Teeswater (S) Qy | unknown | NO | 17T | 479700E 4866000N | Culross | I | 11–12 | Wingham | N | unknown | Amherstburg |
| W-06 | Holliday's Qy | unknown | NO | 17T | 456000E 4843000N | Colborne | II–III | 15 | Wingham | N | 3.0 m | Dundee |
| W-07 | Belgrave Qy | unknown | NO | 17T | 473500E 4850000N | Morris | IV | 9 | Wingham | N | 2.0 m | Amherstburg ? |
| W-08 | Robert Miller Qy | Robert Miller | NO | 17T | 480300E 4840500N | Grey | XII | 5 | Wingham | N | 4.0 m | Amherstburg ? |
| W-09 | V. Grahmn Qy | V. Grahmn | NO | 17T | 484000E 4839500N | Grey | XI | 14 | Wingham | N | 2.5 m | Amherstburg ? |
| W-10 | Gorrie Qy # 1 | unknown | NO | 17T | 489800E 4857100N | Howick | VIII | 2 | Wingham | N | unknown | Amherstburg |
| W-11 | Robert Ashton Qy | Robert Ashton | NO | 17T | 493200E 4858200N | Howick | VIII | 11 | Wingham | N | 6.0 m | Amherstburg |
| W-12 | Gorrie Qy # 2 | unknown | NO | 17T | 494250E 4857100N | Howick | VII | 13 | Wingham | N | 4.0 m | Amherstburg ? |
| W-13 | W.G. Hamilton Qy | W.G. Hamilton | NO | 17T | 496000E 4856000N | Howick | VII | 17 | Wingham | N | 6.0 m | Amherstburg ? |
| W-14 | Fordwich Qy | unknown | NO | 17T | 497500E 4857050N | Howick | VI–VII | 18 | Wingham | N | unknown | Amherstburg ? |

* Y = yes; N = no; I = intermittent

| Site No. | Quarry Name | Operator or Owner | MNR Lic | UTM | Coords | Township | Conc | Lot | MNR District | Active (*) | Thick-ness | Geological Formation(s) (Members) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W-15 | Cromarty Qy | Anthony Allen | NO | 17T | 470000E 4808350N | Hibbert | XI | 19 | Wingham | N | 2.0 m | Dundee |
| W-16 | Thames Qy | Thames Qy Co. | NO | 17T | 488000E 4788500N | Blanshard | Thames River Conc. | 35 | Wingham | N | 13.0 m | Dundee |
| W-17 | St Marys Qy # 1 | Standard White Lime Co. | NO | 17T | 489200E 4790300N | Blanshard | XVIII | 15 | Wingham | N | 11.0 m | Lucas |
| W-18 | St Marys Qy # 2 | Standard White Lime Co. | NO | 17T | 492200E 4791000N | Downie | XIV | 6 | Wingham | N | 2.0 m | Lucas |
| W-19 | Wildwood Con. Area Qy | unknown | NO | 17T | 493400E 4790050N | Downie | XIV | 2 | Wingham | N | 3.0 m | Lucas |

Note: Marble quarries and processing plant are not included in this inventory. Therefore some site numbers may not be listed, or may not correspond to the map numbers in the district inventories in Volumes II and III.

- The owner/operator for unlicensed quarries may be the current or last known owner/operator.
- Determination of active, non-active or intermittent operation status was made at the time of field work.
- Township names may be geographic or municipal township names.

---

* Y = yes; N = no; I = intermittent

# Volume

# 2

# Limestone Industries of Ontario

## Volume II — Limestone Industries and Resources of Eastern and Northern Ontario

Ontario

Ministry of
Natural
Resources

Vincent G. Kerrio
Minister

Ministry of
Northern Development
and Mines

Sean Conway
Minister

# LIMESTONE INDUSTRIES OF ONTARIO

## Volume I — Geology, Properties and Economics

Paleozoic Geology of Ontario

Precambrian Carbonate Resources

Properties, Specifications and Uses

Production, Economics and Markets

## Volume II — Limestone Industries and Resources of Eastern and Northern Ontario

Eastern Ontario

- *Cornwall District*
- *Carleton Place District*
- *Brockville District*
- *Napanee District*
- *Tweed District*
- *Pembroke District*

Northern Ontario

- *Espanola District*
- *Blind River District*
- *Cobalt District*
- *Moosonee District*

## Volume III — Limestone Industries and Resources of Central and Southwestern Ontario

Central Ontario

- *Lindsay and Minden Districts*
- *Huronia District*
- *Maple District*
- *Cambridge District*
- *Niagara District*

Southwestern Ontario

- *Owen Sound District*
- *Simcoe District*
- *Aylmer District*
- *Wingham District*
- *Chatham District*

# Limestone Industries of Ontario

## Volume II — Limestone Industries and Resources of Eastern and Northern Ontario

Prepared for the Aggregate Resources Section,
Land Management Branch, Ontario Ministry of Natural Resources

by
Derry Michener Booth and Wahl
and
Staff of the Engineering and Terrain Geology Section, Ontario Geological Survey,
Ministry of Northern Development and Mines

1989

Ontario

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Natural
Resources

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*Cover photo of St. Marys Cement plant is courtesy of St. Marys Cement.*

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The authors are indebted to industry personnel and landowners who allowed close examination of their properties, and who generously provided product lists and plant flowcharts.

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Staff of the Engineering and Terrain Geology Section, Ontario Geological Survey of the Ministry of Northern Development and Mines prepared the geological description of each site as well as the regional descriptions of the geology of limestone and related carbonate rocks in Volume I. This work was supervised by Dr. Owen White, Chief, Engineering and Terrain Geology Section, and Mike Johnson, Acting Supervisor, Paleozoic/Mesozoic Geology Sub–Section. Staff involved in preparing the site descriptions included Dr. Max Vos, Rainer Wolf, Ruth Bezys, Derek Armstrong, Julie Stevenson–Demeester, Val Mazur, and Chris Fouts. Dr. Peter Telford of the Mineral Development and Lands Branch, Ministry of Northern Development and Mines assisted in the interpretation of geological data and the review of the report.

The project was initiated by the Aggregate Resources Section, Ministry of Natural Resources, under the direction of Dale Scott. Geoff Bell was the project coordinator and report editor.

# Preface

Products from the limestone industries find their way into many of the items that are essential to our modern way of life. In one way or another, the output of the various members of the limestone industries is used in constructing or manufacturing items as diverse as office towers, homes, transportation networks, steel, glass, paper, or rubber products.

This report examines Ontario's limestone industries from two perspectives: the geological resource, including limestone, dolostone, marble and carbonatites; and secondly, the various industries which rely on these resources to manufacture products which are vital to Ontario's economy. These products include construction aggregate, cement, lime, fillers and extenders, building stone and pulverized stone.

In order to undertake a study on such a large and important economic sector, a steering committee was struck to formulate the terms of reference for the study and guide the research and field work through to the report stage. Members of the steering committee were:

- ☐ Dale Scott, Chairman, Ministry of Natural Resources
- ☐ Norris Walker, Aggregate Producers' Association of Ontario
- ☐ Vic Perry, Canadian Portland Cement Association
- ☐ Don Stonehouse, Energy Mines and Resources Canada
- ☐ Dr. Owen White, Ministry of Northern Development and Mines
- ☐ Dr. Peter Telford, Ministry of Northern Development and Mines
- ☐ Dr. Max Vos, Ministry of Northern Development and Mines
- ☐ Mike Johnson, Ministry of Northern Development and Mines
- ☐ Zoltan Katona, Ministry of Transportation
- ☐ Chris Rogers, Ministry of Transportation
- ☐ Geoff Bell, Executive Secretary, Ministry of Natural Resources

The study brings together the most up to date geological information pertaining to carbonate rocks and describes the current operations of the members of the limestone industry. In addition, information on the economics of the various commodities is presented in order to give a more complete picture of this resource activity. Field work and data compilation were performed in 1986 and 1987. The authors have attempted to incorporate changes in plant design and ownership up until summer 1988.

The geological and plant site descriptions are organized based on the Ministry of Natural Resources administrative districts. This approach was taken to accommodate the multi–commodity nature of the industry, as well as to facilitate review of the material. This format also allows district updates of activity to be produced easily at a future date.

Metric units are used in the geological descriptions throughout the report, and in parts of the plant and operations descriptions. Since plant equipment is normally sized in Imperial units, these measurements have not been converted to metric units for ease of presentation.

# Contents

**Introduction** 1

**Part 1 Eastern Ontario** 3
Cornwall District 4
Introduction 4
Regional Geology 5
Limestone Industries 8
CW–1 Barry Forbes — Forbes Quarry 8
CW–2 M. Fetterley - Cornwall Gravel Co. Ltd. — Iroquois Quarry 9
CW–3 Cruickshank Construction Ltd. — Williamsburgh Quarry 10
CW–4 A.L. Blair Construction Co. Ltd. — St. Albert Station Quarry 11
CW–5 A.L. Blair Construction Co. Ltd. — Embrun Quarry 14
CW–6 Dibblee Construction Co. Ltd. — Limoges Quarry 15
CW–7 Township of Clarence — Canaan Quarry 16
CW–8 Rockland (Stewart) Quarry 17
CW–9 Cornwall Gravel Company Ltd. — Richier Quarry 18
CW–10 A.L. Blair Construction Co. Ltd. — McLean (Finch) Quarry 19
CW–11 A.L. Blair Construction Co. Ltd. — Plumadore Quarry 19
CW–12 Permanent Concrete — Cornwall Quarry 20
CW–13 Dibblee Construction Co. Ltd. — Cornwall Quarry 22
CW–14 Cornwall Gravel Company Ltd. — MacLeod Quarry 23
CW–15 A.L. Blair Construction Co. Ltd. — Christie Quarry 27
CW–16 A.L. Blair Construction Co. Ltd. — Gravel Hill Quarry 27
CW–17 A.L. Blair Construction Co. Ltd. — Moose Creek Quarry 28
CW–18 A.L. Blair Construction Co. Ltd. — Martin (Tayside) Quarry 28
CW–19 Bertrand & Freres Construction Company Ltd. — St. Isidore Quarry 29
CW–20 R. Tierney — Tierney Quarry 30
CW–21 Bertrand & Freres Construction Company Ltd. — L'Orignal Quarry 30
CW–22 Sintra Inc. — Ross Quarry 32
CW–23 Cliftondale Aggregates — Cliftondale (McAlpine) Quarry 33
CW–24 Sintra Inc. — Leroux (Skye) Quarry 34
CW–25 Cruickshank Construction Ltd. — Gauthier Quarry 36
CW–26 A.L. Blair Construction Co. Ltd. — Duval Quarry 36
CW–27 Cruickshank Construction Ltd. — Green Valley Quarry 38
CW–28 Karnuk Marble Industries Inc. — Cornwall Plant 39
Carleton Place District 42
Introduction 42
Regional Geology 43
Limestone Industries 46
CP–1 Thomas Cavanagh Construction Ltd. — Arnprior Quarry 47
CP–2 Thomas Cavanagh Construction Ltd. — Kinburn Quarry 47
CP–3 R.C. Lyle (Burntlands Aggregate Ltd.) — Almonte Quarry 48
CP–4 Thomas Cavanagh Construction Ltd. — West Carleton Quarry 48
CP–5 Duffy Road Oiling Ltd. — Carleton Place Quarry 49
CP–6 George Kennedy — Dunrobin Quarry 50

CP-7 Thomas Cavanagh Construction Ltd. — Franktown Quarry . . . . . 51
CP-8 Warren Paving & Materials Group Ltd. — Smiths Falls (Dibblee) Quarry . . . . . 52
CP-9 Spratt Sand and Gravel Ltd. — Spratt Quarry . . . . . 53
CP-10 West Carleton Sand and Gravel Inc. — Clarke Quarry . . 55
CP-11 Thomas Cavanagh Construction Ltd. — Goulbourn Quarry . . . . . 57
CP-12 G. Tackaberry and Sons Construction Co. Ltd. — Rosedale Quarry . . . . . 58
CP-13 G. Tackaberry and Sons Construction Co. Ltd. — Kilmarnock Quarry . . . . . 58
CP-14 R.W. Tomlinson Ltd. — Fallowfield Quarry . . . . . 59
CP-15 George Wimpey Canada Ltd. — Moodie Drive (Fallowfield) Quarry . . . . . 60
CP-16 Warren Paving & Materials Group Ltd. — Houlahan (Fallowfield) Quarry . . . . . 63
CP-17 United Aggregates Ltd. — South Gloucester Quarry . . . . 64
CP-18 Warren Paving & Materials Group Ltd. — Boyce (South Gloucester) Quarry . . . . . 67
CP-19 Beaver Asphalt Paving Co. Ltd. — Ottawa (South Gloucester) Quarry . . . . . 68
CP-20 Permanent Concrete — Hawthorne Road Quarry . . . . . . 71
CP-21 Cornwall Sand & Gravel Company — Greely Quarry . . . 73
CP-22 Francon Division Of Canfarge Ltd. — North and South (Francon) Quarries . . . . . 74
CP-23 Permanent Concrete — Navan (Leblanc) Quarry . . . . . . 77
CP-24 Bertrand & Freres Construction Company Ltd. — Sarsfield Quarry . . . . . 77
CP-25 Steep Rock Calcite — Tatlock Quarry . . . . . 78
Brockville District . . . . . 82
  Introduction . . . . . 82
  Regional Geology . . . . . 83
  Limestone Industries . . . . . 84
  BR-1 Griffin Bros. (Gananoque) Ltd. — Lynn (Westport) Quarry . . . . . 85
  BR-2 G. Tackaberry and Sons Construction Company Limited — Harlem Quarry . . . . . 86
  BR-3 G. Tackaberry and Sons Construction Company Limited — O'Grady Quarry . . . . . 87
  BR-4 O. Shirley and Sons — Shirley Quarry . . . . . 87
  BR-5 G. Tackaberry and Sons Construction Company Limited — Willows (Newbliss) Quarry . . . . . 88
  BR-6 G. Tackaberry and Sons Construction Company Limited — Ronan (Leeds) Quarry . . . . . 88
  BR-7 G. Tackaberry and Sons Construction Company Limited — Mercier (Frankville) Quarry . . . . . 89
  BR-8 G. Tackaberry and Sons Construction Company Limited — Lawson (Athens No. 2) Quarry . . . . . 90
  BR-9 G. Tackaberry and Sons Construction Company Limited — Jasper Quarry . . . . . 92
  BR-10 William Clow — Sherwood Springs Quarry . . . . . 93
  BR-11 G. Tackaberry and Sons Construction Company Limited — Woods (Tincap) Quarry . . . . . 94
  BR-12 Permanent Concrete — Brockville Quarry . . . . . 95
  BR-13 Warren Paving and Materials Group Limited — Brockville Quarry . . . . . 96

BR-14 G. Tackaberry and Sons Construction Company Limited — Wings (Maitland) Quarry ... 96
BR-15 Maple Grove (Kemptville) Ltd. — Kemptville Quarry ... 97
Napanee District ... 98
  Introduction ... 98
  Regional Geology ... 98
  Limestone Industries ... 102
  NP-1 St. Lawrence Cement Company Inc. — Ogden Point Quarry ... 102
  NP-2 Trenton Gravel Products Ltd. — Consecon Quarry ... 106
  NP-3 H.J. McFarland Construction Co. — Mountain View Quarry ... 106
  NP-4 Harvey Putnam — Cannifton Quarry ... 107
  NP-5 H.J. McFarland Construction Co. — Point Anne (Belleville) Quarry ... 108
  NP-6 H.J. McFarland Construction Co. — Long Quarry ... 109
  NP-7 Lake Ontario Cement Ltd. — Picton Quarry and Plant ... 110
  NP-8 Miller Paving Limited — Prince Edward (Picton) Quarry ... 114
  NP-9 Trenton Gravel Products Ltd. — Napanee Quarry ... 115
  NP-10 H.J. McFarland Construction Co. — Roblindale Quarry ... 116
  NP-11 Custom Mobile Concrete — Selby Quarry ... 117
  NP-12 J.R. Storey Construction Ltd. — Napanee Quarry ... 118
  NP-13 J.C. Dennison — Napanee Quarry ... 119
  NP-14 Griffin Brothers (Gananoque) Ltd. — Dillon Quarry ... 120
  NP-15 Township of Camden East — Camden East Quarry ... 121
  NP-16 J.R. Storey Construction Ltd. — Morven Quarry ... 122
  NP-17 J.C. Denison — Storms Corners Quarry ... 122
  NP-18 Lafarge Canada Inc. — Bath Quarry and Plant ... 123
  NP-19 F.G. Bezanson and Son Ltd. — Wilton Quarry ... 126
  NP-20 Township of Amherst Island — Amherst Island (Caughey) Quarry ... 127
  NP-21 Portland Township (Hartington) Quarry ... 127
  NP-22 W.J. McKendry and Sons Limited — Westbrook Quarry ... 128
  NP-23 Wood's Sand And Gravel Ltd. — Collins Bay Quarry ... 129
  NP-24 H.J. McFarland Construction Company — Kingston Quarry ... 132
  NP-25 Township of Kingston — Kingston Quarry ... 133
  NP-26 W.J. McKendry And Sons Ltd. — Cranston (Kepler) Quarry ... 133
  NP-27 Frontenac Aggregates and Construction — Elginburg Quarry ... 134
  NP-28 Spaffordton Quarry ... 136
  NP-29 W.J. McKendry and Sons Limited — Glenburnie (Kingston) Quarry ... 136
  NP-30 Wood's Sand and Gravel Limited — Macadoos Lane (Glen Lawrence) Quarry ... 138
  NP-31 H.J. McFarland Construction Company— Macadoos Lane (Bilow) Quarry ... 140
  NP-32 Frontenac Aggregates and Construction — Pittsburgh Quarry ... 140
  NP-33 Mill Point Quarry ... 143
  NP-34 Griffin Brothers (Gananoque) Ltd. — Battersea Quarry ... 143
  NP-35 Griffin Brothers (Gananoque) Ltd. — Joyceville Quarry ... 144
  NP-36 Howe Island Quarry ... 146
  NP-37 Warren Paving and Materials Group Limited — Westbrook Quarry ... 146
Tweed District ... 148
  Introduction ... 148

Precambrian Geology 149
Paleozoic Geology 149
Limestone Industries 150
TW–1 Marmoraton Mining Company — Marmora Pit 150
TW–2 Stoklosar Marble Quarries Limited — Jarvis Lake Quarry 152
TW–3 Stoklosar Marble Quarries Limited — Madoc Marble Quarry 153
TW–4 H.J. McFarland Construction Co. — Crookston Quarry 154
TW–5 Stoklosar Marble Quarries Limited — Fox Corners Pink Marble Quarry 155
TW–6 Stoklosar Marble Quarries Limited — Madoc Green Marble Quarry 156
TW–7 Stoklosar Marble Quarries Limited — Madoc Grey–Black Marble Quarry 157
TW–8 Stoklosar Marble Quarries Limited — Madoc Buff Marble Quarry No. 1 158
TW–9 Stoklosar Marble Quarries Limited — Madoc Buff Marble Quarry No. 2 159
TW–10 Stoklosar Marble Quarries Limited — Madoc Black Marble Quarry 160
TW–11 Stoklosar Marble Quarries Limited — Marmora Brucitic Marble Quarry 160
TW–12 Stoklosar Marble Quarries Limited — Keller Bridge Blue Marble Quarry 161
TW–13 Stoklosar Marble Quarries Limited — Eldorado Light Buff Marble Quarry 162
TW–14 Stoklosar Marble Quarries Limited — Eldorado Dark Buff Marble Quarry 162
TW–15 Stoklosar Marble Quarries Limited — Madoc Plant No. 1 163
TW–16 Stoklosar Marble Quarries Limited — Madoc Plant No. 2 164
TW–17 Canada Talc Limited — Madoc Talc Mine 165
Pembroke District 166
Introduction 166
Regional Geology 167
Limestone Industries 168
PE–1 Fourth Chute Quarry 168
PE–2 Smiths Construction Co. Ltd. — Braeside Quarry 169
PE–3 H&H Aggregates Co. Ltd. — Clay Bank Quarry 170
PE–4 Timminco Limited — Haley Station Quarry No. 1 170
PE–5 Timminco Limited — Haley Station Quarry No. 2 171
PE–6 Timminco Limited — Haley Station Plant 172

**Part 2 Northern Ontario** 175
Espanola District 176
Introduction 176
Paleozoic Geology 176
ES–1 Standard Aggregates Inc. — Manitoulin (Meldrum Bay) Quarry 176
ES–2 Hercules Ornamental Stone — Foxey Quarry 182
ES–3 Cup and Saucer Quarry 182
Blind River District 184
Introduction 184
BL–1 Reiss Lime Company of Canada Ltd. — Spragge Plant 184
Cobalt District 185
Introduction 185
Paleozoic Geology 185

CO–1 Nortario Limestone Ltd. — McNammaras Quarry ...... 186
CO–2 Township of Harley Quarry ........................ 187
CO–3 Hanbury Quarry ................................... 188
CO–4 Dymond Clay Products Ltd. — Bucke Quarry ......... 188
CO–5 Farr Quarry ...................................... 189
Moosonee District ...................................... 191
Introduction ........................................... 191
Paleozoic Geology ...................................... 191
MO–1 M.J. Labelle Co. Ltd. — Moosonee Quarry .......... 191

**References Cited** ........................................ **193**

# Introduction

Ontario is fortunate in possessing ample resources of limestone and related carbonate rocks, including dolostone, marble and carbonatite. The rocks, which consist primarily of calcium carbonate, have many uses in today's economy. This report examines Ontario's limestone resources as well as the industries which rely on them: crushed stone aggregates; cement; lime, chemical and metallurgical stone; fillers and extenders; building stone; and pulverized stone. These industries supply the materials upon which Ontario's construction and transportation infrastructure rely. In addition, many limestone products are used in industrial processes which manufacture a host of products such as steel, chemicals, paper and composite materials.

This report attempts to capture the many aspects of the resource sector. The geology of Ontario's carbonate rocks has received considerable attention over the last fifteen years. Part 1 of Volume I deals with the geology of Paleozoic limestone formations on a regional scale. Part 1 integrates all the recent interpretation of stratigraphy, lithology and nomenclature. This is particularly important in southeastern Ontario which relies heavily on bedrock aggregates because of a shortage of sand and gravel aggregate. The geology of southeastern Ontario has been analyzed in depth by geologists of the Ontario Geological Survey over the past eight years. The latest interpretation of the bedrock formations is presented. Part 2 describes the geology of marble deposits in southeastern Ontario, and carbonatites in northern Ontario, as well as calcite veins and marl deposits.

Part 3 of Volume I describes the main limestone industries in Ontario. The commodities of the various sectors are examined in light of physical characteristics, processing techniques, end–uses and specifications of products.

Part 4 describes the economics of each of the limestone industries, and deals with factors such as energy and transportation costs, prices, and competing products which determine the viability and competitiveness of the various products. An outlook for the commodities is given.

Volumes II and III of the report describe the geology, plant, processing and products of the active members of the industry. Volume II includes the operations which are located in northern and southeastern Ontario. Volume III examines the sites in south central and southwestern Ontario. The two volumes consist of detailed site–by–site inventories of each operation. The site inventories include a geological interpretation of the exposed rock in the quarry, a description of the operator's quarry operations and stone processing plant, plus a products list and in many instances a plant flowchart. In addition to commercial sites, many sites with important geological features are included in the inventory.

In the almost thirty years since the late Don Hewitt authored the first study of this type (Hewitt, 1960), many changes have taken place in Ontario's economy. The limestone industries have kept pace with this change, achieving higher production rates with lower energy, labour and raw material input. The primary value for the various products manufactured by the limestone industries is currently approaching one billion dollars annually. The limestone industries are positioned to remain a vital segment of Ontario's economy well into the 21st century.

# Part 1
# Eastern Ontario

# Cornwall District

## INTRODUCTION

Cornwall District is situated in the Eastern Region of southern Ontario and is bounded by the Ottawa River, the Province of Quebec, the St. Lawrence River and MNR Districts of Brockville and Carleton Place. The district includes the United Counties of Prescott and Russell, and the United Counties of Stormont, Dundas and Glengarry, as shown in Figure CW–0–1.

Sixty–eight quarries are documented in the Cornwall District quarry inventory (Appendix IV, Volume I); fourteen are currently active, twelve operate intermittently and the balance represent past producing quarries or those properties identified for future production.

Twenty–seven quarries and one marble plant were visited during the study and include the following:

| | |
|---|---|
| *CW–1* | *Barry Forbes – Forbes Quarry (active)* |
| *CW–2* | *M. Fetterley – Cornwall Gravel Co. Ltd. – Iroquois Quarry (active)* |
| *CW–3* | *Cruickshank Construction Ltd. – Williamsburgh Quarry (active)* |
| *CW–4* | *A.L. Blair Construction Co. Ltd. – St. Albert Station Quarry (active)* |
| *CW–5* | *A.L. Blair Construction Co. Ltd. – Embrun Quarry (active)* |
| *CW–6* | *Dibblee Construction Co. Ltd. – Limoges Quarry (intermittent)* |

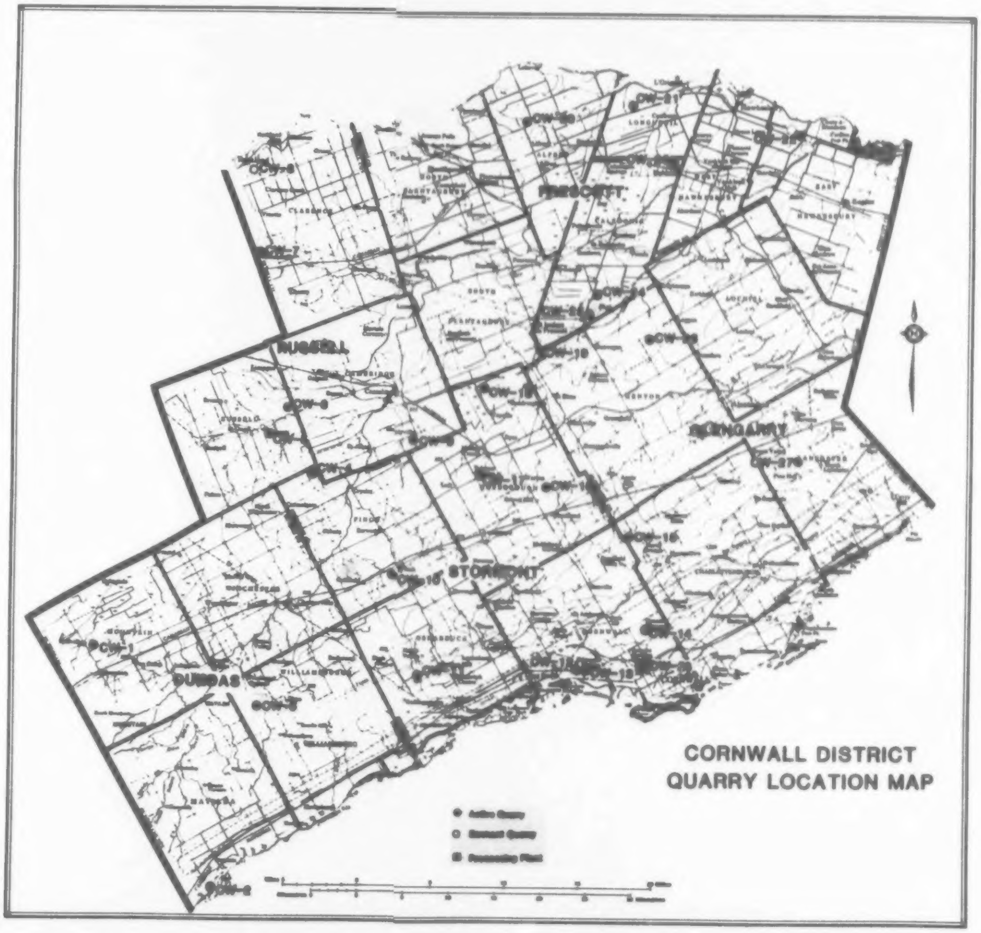


Figure CW–0–1. CORNWALL DISTRICT QUARRY LOCATION MAP.

| | |
|---|---|
| *CW–7* | *Township of Clarence – Canaan Quarry (active)* |
| *CW–8* | *Rockland (Stewart) Quarry (abandoned)* |
| *CW–9* | *Cornwall Gravel Company Ltd. – Richier Quarry (active)* |
| *CW–10* | *A.L. Blair Construction Co. Ltd. – McLean (Finch) Quarry (intermittent)* |
| *CW–11* | *A.L. Blair Construction Co. Ltd. – Plumadore Quarry (intermittent)* |
| *CW–12* | *Permanent Concrete – Cornwall Quarry (active)* |
| *CW–13* | *Dibblee Construction Co. Ltd. – Cornwall Quarry (intermittent)* |
| *CW–14* | *Cornwall Gravel Company Ltd. – MacLeod Quarry (active)* |
| *CW–15* | *A.L. Blair Construction Co. Ltd. – Christie Quarry (intermittent)* |
| *CW–16* | *A.L. Blair Construction Co. Ltd. – Gravel Hill Quarry (intermittent)* |
| *CW–17* | *A.L. Blair Construction Co. Ltd. – Moose Creek Quarry (intermittent)* |
| *CW–18* | *A.L. Blair Construction Co. Ltd. – Martin (Tayside) Quarry (intermittent)* |
| *CW–19* | *Bertrand & Freres Construction Company Ltd. – St. Isidore Quarry (active)* |
| *CW–20* | *R. Tierney – Tierney Quarry (active)* |
| *CW–21* | *Bertrand & Freres Construction Company Ltd. – L'Orignal Quarry (active)* |
| *CW–22* | *Sintra Inc. – Ross Quarry (intermittent)* |
| *CW–23* | *Cliftondale Aggregates – Cliftondale (McAlpine) Quarry (intermittent)* |
| *CW–24* | *Sintra Inc. – Leroux (Skye) Quarry (intermittent)* |
| *CW–25* | *Cruickshank Construction Ltd. – Gauthier Quarry (intermittent)* |
| *CW–26* | *A.L. Blair Construction Co. Ltd. – Duval Quarry (active)* |
| *CW–27* | *Cruickshank Construction Ltd. – Green Valley Quarry (active)* |
| *CW–28* | *Karnuk Marble Industries Inc. – Cornwall Plant* |

## REGIONAL GEOLOGY

Cornwall District extends westward from the Ontario/Quebec border to a line running north from the town of Cardinal, on the St. Lawrence River, to the Ottawa River (Figure CW–0–1). Along the Ottawa River, north–facing, fault–controlled bedrock escarpments line portions of the river. The rest of the district is underlain by flat–lying Paleozoic strata.

Thick glacial deposits cover most of the district, though in several areas bordering the St. Lawrence and Ottawa Rivers glacial overburden is much thinner or completely absent, revealing the underlying bedrock.

The Cornwall District is underlain by rocks of Upper Cambrian, and Lower, Middle, and Upper Ordovician age. Unlike most of Central Ontario, the Paleozoic rocks have been disrupted by large–scale faults. In the Cornwall District major faults trend west–east along the Ottawa River and northwest– southeast across the interior of the district. Although bedrock exposures are generally limited, drill hole data confirm the presence of many of these faults (Williams, in prep.). Smaller–scale faults are commonly exposed in quarries.

The Paleozoic strata consist of carbonate and clastic sedimentary rocks which are subdivided (Figure CW–0–2) into the following formations (in ascending stratigraphic order).

The Upper Cambrian to Lower Ordovician Potsdam Group consists of the conglomerates and arkoses of the Covey Hill Formation, and the overlying quartz arenites of the Nepean Formation. Only small operations currently utilize these rocks for aggregate and dimensional stone, although historically the sandstones of the Nepean Formation have been used extensively as building material, for example, in the Parliament Buildings in Ottawa.

The overlying Lower Ordovician Beekmantown Group consists of the March and Oxford Formations. The March Formation is transitional between the clastic rocks of the Potsdam Group and the overlying dolostones of the Oxford Formation, and consists of alternating beds of quartz arenite and dolostone, with gradations between the two rock types. Most common are fine–crystalline dolostones which consist of up to 50% medium– to coarse–grained, well–rounded quartz grains, which "float" in the dolostones. The lower contact of the March Formation is placed at the base of the lowest dolostone bed (Williams, in prep.); the formation thickens from 20 m in the west to 60 m in the east.

In Eastern Ontario, the March Formation has been quarried extensively over the years although there is currently no production from the formation in the Cornwall District. Large blocks of sandy dolostone were utilized in the construction of the Rideau Canal system in the 1830s and those strata as well as dolostone beds were also quarried for building and ornamental stone. In addition to being a source for crushed stone in recent years, the sandy dolostone beds have proven to be an excellent source of skid–resistant aggregate (Rogers, 1980).

The Oxford Formation consists of grey–brown, microcrystalline to medium–crystalline, medium–bedded dolostones. Scattered, coarse–grained quartz sand and sandy interbeds (up to 30 cm thick) are present in the lower part of the formation. Calcite–filled vugs of varying sizes are common in most intervals – small, white chert nodules are less common. The lower contact of the Oxford Formation is placed at the top of the uppermost sandstone bed in the underlying March Formation (Wil-

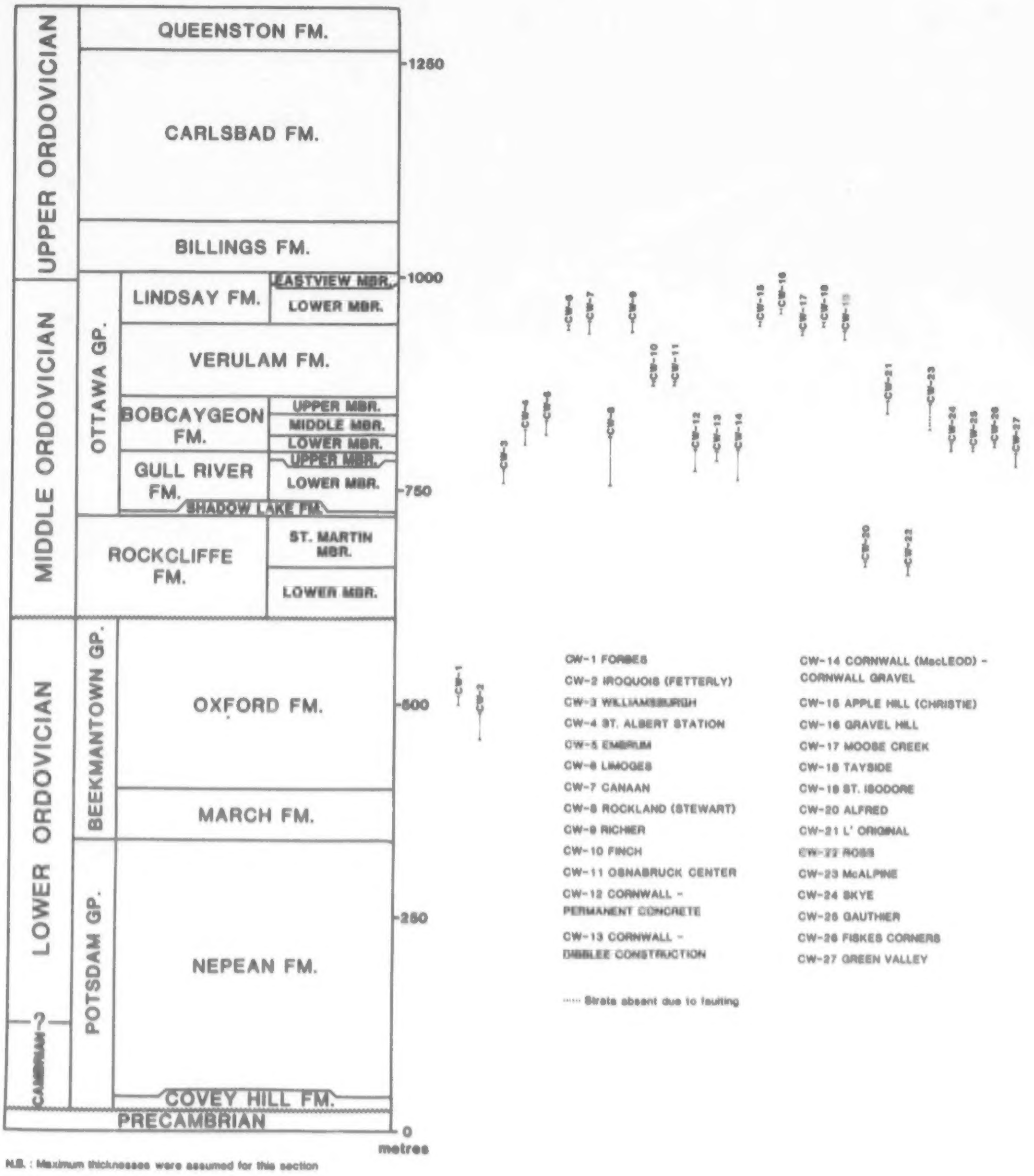

UPPER ORDOVICIAN
MIDDLE ORDOVICIAN
LOWER ORDOVICIAN
CAMBRIAN
?
OTTAWA GP.
BEEKMANTOWN GP.
POTSDAM GP.
QUEENSTON FM.
CARLSBAD FM.
BILLINGS FM.
LINDSAY FM.
EASTVIEW MBR.
LOWER MBR.
VERULAM FM.
BOBCAYGEON FM.
UPPER MBR.
MIDDLE MBR.
LOWER MBR.
GULL RIVER FM.
UPPER MBR.
LOWER MBR.
SHADOW LAKE FM.
ROCKCLIFFE FM.
ST. MARTIN MBR.
LOWER MBR.
OXFORD FM.
MARCH FM.
NEPEAN FM.
COVEY HILL FM.
PRECAMBRIAN
1250
1000
750
500
250
0
metres
N.B. : Maximum thicknesses were assumed for this section
CW-1 FORBES
CW-2 IROQUOIS (FETTERLY)
CW-3 WILLIAMSBURGH
CW-4 ST. ALBERT STATION
CW-5 EMBRUM
CW-6 LIMOGES
CW-7 CANAAN
CW-8 ROCKLAND (STEWART)
CW-9 RICHIER
CW-10 FINCH
CW-11 OSNABRUCK CENTER
CW-12 CORNWALL - PERMANENT CONCRETE
CW-13 CORNWALL - DIBBLEE CONSTRUCTION
CW-14 CORNWALL (MacLEOD) - CORNWALL GRAVEL
CW-15 APPLE HILL (CHRISTIE)
CW-16 GRAVEL HILL
CW-17 MOOSE CREEK
CW-18 TAYSIDE
CW-19 ST. ISODORE
CW-20 ALFRED
CW-21 L' ORIGINAL
CW-22 ROSS
CW-23 McALPINE
CW-24 SKYE
CW-25 GAUTHIER
CW-26 FISKES CORNERS
CW-27 GREEN VALLEY
...... Strata absent due to faulting

Figure CW-0-2. STRATIGRAPHIC COLUMN SHOWING PRINCIPAL QUARRIES OF CORNWALL DISTRICT.

liams, in prep.). The formation maintains a uniform thickness of 200 m across the district and is quarried for crushed stone along the St. Lawrence River at the Iroquois Quarry (CW–2) and to the north at the Forbes Quarry (CW–1).

Unconformably overlying the Oxford Formation, the Middle Ordovician Rockcliffe Formation is subdivided into two members (Williams, in prep.), a lower clastic and an upper carbonate member. The light grey to green–grey, fine– grained, thin– to thick–bedded, commonly crossbedded, quartz sandstones of the lower member are interbedded with olive green to grey (rarely maroon), laminated shales which contain numerous burrows. The upper St. Martin Member consists of light grey to grey–brown, microcrystalline to fine crystalline limestone to more commonly coarse–grained, thick–bedded, crossbedded calcarenites. The very high calcium content of these limestones along the Ottawa River (Williams, in prep.) increases their potential usefulness. The St. Martin Member also contains thin intervals of grey–brown, shaly to silty dolostone. The formation reaches a maximum thickness of 120 m at the extreme eastern end of the district along the Ottawa River although it rapidly thins westward to an average thickness of 50 m near Ottawa. Each member maintains a sub–equal thickness across the district.

The Rockcliffe Formation is quarried along the Ottawa River at the Alfred Quarry of R. Tierney (CW–20) for ornamental stone and at the Ross Quarry (CW–22) for crushed stone. In the past the limestones of the St. Martin Member were much more extensively quarried (Goudge, 1938).

The Ottawa Group consists of five formations which, except for the Shadow Lake Formation, are extensively utilized by the limestone industry in Cornwall District. The Shadow Lake Formation, which overlies the Rockcliffe Formation with a minor disconformity, is a thin (3 m thick) interval of sandstone and shale which represent the initial deposits of the Ottawa Group.

The Gull River Formation is subdivided into two members, a lower member consisting of interbedded dolostone and limestone and an upper member consisting of shaly limestone. The dolostones of the lower member are grey–brown to grey–green, fine crystalline, thin to medium bedded, and commonly contain some clastic material, ranging from mud to sand sized. Large calcite–filled vugs are common in some beds. The interbedded limestones range from light grey and microcrystalline, commonly with "birdseye" texture, to medium grey, fine to medium crystalline. The lower member thins from 60 m in the west to 40 m in the east. The 10 m thick upper member commonly consists of light grey, microcrystalline to fine–crystalline, thin–bedded limestone, with thin shale interbeds. The colonial coral *Tetradium* is very abundant in this member.

The Gull River Formation is extensively quarried across Cornwall District for crushed stone. The larger quarries include the Williamsburgh Quarry (CW–3), the Cornwall Quarries of Permanent Concrete (CW–12), Dibblee Construction (CW–13) and Cornwall Gravel (CW–14), and the Green Valley Quarry (CW–27). Not all the strata of the lower member can be used for concrete aggregate because of the alkali–reactivity of some of the grey–green dolostone beds (Rogers, 1985).

The Bobcaygeon Formation overlies the Gull River Formation and consists of limestone with shale partings and interbeds of varying thickness and frequency. Three members have been identified in the Bobcaygeon Formation (Williams, in prep.), with the middle member characterized by substantially more shale interbeds than the lower and upper members. The lower member consists of light grey, microcrystalline to fine–crystalline, thick– to massive–bedded limestone, with interbedded intervals of fine– to medium–grained calcarenites. Black chert nodules are common in some beds. Shale partings are very thin, and are not always present between beds. The middle member consists of grey, thin– to medium–bedded, fine– to medium–crystalline limestone and fine– to coarse–grained calcarenite, which are interbedded with shale beds up to 2 cm thick. The upper member, which is rarely exposed, consists of grey, fine– to medium–crystalline, thin– to medium–bedded limestone with rare, thin shale partings. The formation is about 60 to 75 m thick, with each member maintaining a thickness of 20 to 25 m across the district.

Quarries in the Bobcaygeon Formation are concentrated in the lower member, and include the St. Albert Station Quarry (CW–4), the abandoned Rockland Quarry (CW–8), the Leroux Quarry (CW–24), the Gauthier Quarry (CW–25) and the Duval Quarry (CW–26). In addition, the thick limestone beds at the base of the member cap several quarries (see Figure CW–0–2). The middle member is best exposed in the Embrun Quarry (CW–5), while the upper member occurs in the L'Orignal Quarry (CW–21) and the Cliftondale Quarry (CW–23). Many smaller, now abandoned quarries also occur within the strata of the formation across the district.

The Verulam Formation overlies the Bobcaygeon Formation and consists of interbedded limestones and shales. The former range from microcrystalline to medium–crystalline limestone and fine– to coarse–grained calcarenites which occur in thin– to medium–bedded intervals. Coarse–grained horizons of fossil debris commonly occur within the limestone beds. The shales are commonly calcareous with abundant fossils and burrows and occur in beds up to 15 cm thick. The formation thickens from 40 to 60 m eastward across the district.

The high shale content and lack of exposures have inhibited extensive quarrying of the Verulam Formation. Several small quarries do utilize this rock for crushed stone, including the McLean (CW–10) and the Plumadore (CW–11) Quarries.

The Lindsay Formation is a limestone with thin calcareous shale interbeds which conformably overlies the Verulam Formation. The Lindsay Formation is divisible into two members: the lower (un–named) member – a nodular limestone with thin calcareous shale partings – and the upper Eastview Member – a black, petroliferous, calcareous shale. The limestones are commonly microcrystalline to medium crystalline with interbedded medium– to coarse–grained calcarenites which occur in thin to thick beds. The upper Eastview Member can be very shaly and exudes a petroliferous odour from a fresh surface. Across the district both the lower and upper members maintain a uniform thickness, 50 m for the lower and 10 m for the upper member.

The limestones of the lower member are a significant source of crushed stone in the Cornwall District. The major quarries include the Limoges Quarry (CW–6), the Canaan Quarry (CW–7), the Richier Quarry (CW–9), the Christie Quarry (CW–15), the Gravel Hill Quarry (CW–16), the Moose Creek Quarry (CW–17), the Martin Quarry (CW–18) and the St. Isidore Quarry (CW–19). The Eastview Member is not utilized by the limestone industry.

The overlying Upper Ordovician strata, the Billings, Carlsbad, and Queenston Formations primarily consist of shale, with some limestone in the Carlsbad Formation, totalling approximately 300 m of strata. These formations are not currently utilized by the limestone industry, although the red shales of the Queenston Formation are used by the ceramic and brick industry.

## LIMESTONE INDUSTRIES

The limestone industries in the Cornwall District are construction aggregate and building stone. Stone production in 1985, as reported by the 1986 Ontario Mineral Score, amounted to some 1,615,000 tonnes and was principally used in the construction industry as road and concrete aggregate.

Approximately 832,000 tonnes were produced in the United Counties of Prescott and Russell and includes production from A.L. Blair Construction Co. Ltd. – Embrun Quarry (CW–5), Township of Clarence – Canaan Quarry (CW–7), Cornwall Gravel Company Ltd. – Richier Quarry (CW–9), Bertrand & Freres Construction Company Ltd. – St. Isidore Quarry (CW–19) and L'Orignal Quarry (CW–21), R. Tierney – Tierney Quarry (CW–20), Sintra Inc. – Ross Quarry (CW–22) and Leroux (Skye) Quarry (CW–24), Cliftondale Aggregates – Cliftondale (McAlpine) Quarry (CW–23) and Cruickshank Construction Co. Ltd. – Gauthier Quarry (CW–25). With the exception of Cornwall Gravel Company Ltd. – Richier Quarry (CW–9) and Bertrand & Freres Construction Company Ltd. – L'Orignal Quarry (CW–21), each reporting production in excess of 100,000 tonnes per year, the aforementioned quarries each reported annual production of less than 50,000 tonnes per year.

Stone production in the United Counties of Stormont, Dundas and Glengarry was reported to be in the order of 783,000 tonnes and includes production from Barry Forbes – Forbes Quarry (CW–1), M. Fetterley/Cornwall Gravel Co. Ltd. – Iroquois Quarry (CW–2), Cruickshank Construction Ltd. – Williamsburgh Quarry (CW–3) and Green Valley Quarry (CW–27), A.L. Blair Construction Co. Ltd. – St. Albert Station Quarry (CW–4), McLean (Finch) Quarry (CW–10), Plumadore Quarry (CW–11), Christie Quarry (CW–15), Gravel Hill Quarry (CW–16), Moose Creek Quarry (CW–17), Martin (Tayside) Quarry (CW–18), Duval Quarry (CW–26), Permanent Concrete – Cornwall Quarry (CW–12), Dibblee Construction Co. Ltd. – Cornwall Quarry (CW–13) and Cornwall Gravel Company Ltd. – MacLeod Quarry (CW–14). The majority of the production, however, is derived from A.L. Blair Construction Ltd. – St. Albert Station Quarry (CW–4), Permanent Concrete –Cornwall Quarry (CW–12) and Cornwall Gravel Company Ltd. – MacLeod Quarry (CW–14) each reporting production in excess of 100,000 tonnes per year. The remaining quarries each reported annual production of less than 50,000 tonnes per year. On a total annual production basis, A.L. Blair Construction Co. Ltd., reporting production from nine quarry–properties, is the largest single producer in the United Counties of Stormont, Dundas and Glengarry.

Building stone production is intermittent and is currently being produced by Cornwall Gravel Company Ltd. at their MacLeod Quarry (CW–14), on request from Karnuk Marble Industries Inc. (CW–28) of Cornwall. The massive black limestone is extensively used in the making of polished tiles.

## CW–1 BARRY FORBES — FORBES QUARRY

### LOCATION AND OWNERSHIP

The Forbes Quarry is located 1 km east of Hallville, in the west half of Lot 8, Concession 8, Mountain Township, Dundas County (Figure CW–1–1). The quarry was opened in 1981 by Barry Forbes, the owner and operator, and is licensed for an area of 40 ha.

### GEOLOGY

The 8 m deep quarry exposes fine–crystalline dolostones of the Oxford Formation which commonly contain cal-

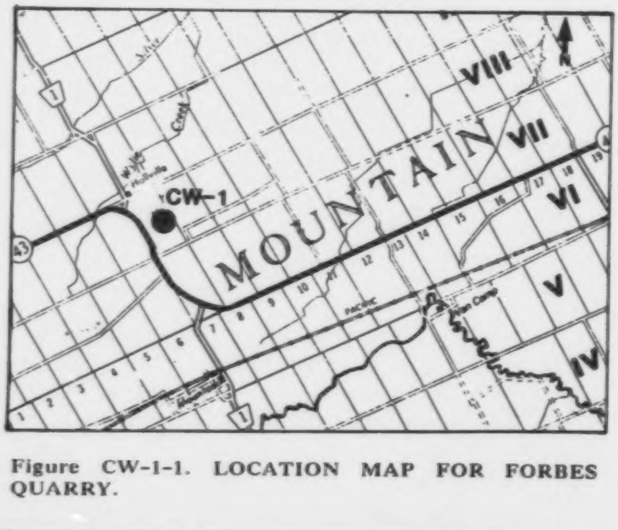


Figure CW–1–1. LOCATION MAP FOR FORBES QUARRY.

cite-filled vugs of varying sizes. Glacial overburden around the quarry is less than 2 m thick.

### Geological Section

*Thickness*

*UNIT 2 Oxford Formation* *5.0m*

Dolostone: light grey-green to medium grey-brown, weathers buff; fine crystalline; thin to medium bedded, with sharp and planar contacts, thin shale partings present between some beds; calcite-filled vugs present in some beds; lower contact of unit sharp and planar.

*UNIT 1 Oxford Formation* *3.0m*

Dolostone: light grey-green to medium grey-brown, weathers buff; fine crystalline; medium to thick bedded; calcite-filled vugs present.

*Total thickness* *8.0m*

### QUARRY OPERATION

The disturbed area of the quarry is approximately 5 ha, presently worked on two lifts of 9 m each. The first lift is drilled on a 2.7 m x 2.7 m pattern with 7.6 cm diameter holes and produces only Granular "A" stone. The second (lower) lift is drilled on a 2.1 m x 2.1 m pattern with 7.6 cm diameter holes and is used to produce concrete stone and HL4 and 5. Drilling and blasting is contracted; crushing is performed by the owner.

### PROCESSING

A Cat 966 loader (3 1/2 yd.) is used to haul stone from the blast face to the portable crushing plant. Primary crushing is carried out with a 30 in. x 42 in. Cedarapids jaw crusher, and a Cedarapids Commander crusher is used to further process the stone. An 80-ton Canadian scale with digital print-out is stationed at the Forbes Quarry.

### PRODUCTS

Pit Run Gravel
Granular "A" and "B"
1 1/4 in. Clear
3/4 in. Clear
1/2 in. Clear
Concrete Sand
Screened Sand
5/8 in. Traffic Bond Stone
1/2 in. Traffic Bond Stone
3/8 in. Chips
Stone Dust
Top Soil Screened
Unscreened Fill
HL4 and 5

### REFERENCES

Williams, in prep., Appendix 1 - Section LQ KE-2

### MAPS

Carson, 1982d, OGS Map P.2493

## CW-2 M. FETTERLEY - CORNWALL GRAVEL CO. LTD. — IROQUOIS QUARRY

### LOCATION AND OWNERSHIP

This large quarry is located in Lots 30 and 31, Range 1, Matilda Township, Dundas County, 2.5 km southwest of the Village of Iroquois (Figure CW-2-1).

The quarry was first opened in 1955 by Iroquois Rock Company, coinciding with the St. Lawrence Seaway Project (1955-59). Much of the stone produced at the quarry during that period was used either in the construction of the seaway or in the relocation of public/private property and facilities, i.e. relocation of the CN railway line from Cardinal to Cornwall. The quarry also supplied concrete stone for the construction of the Ogdensberg to Johnstown bridge in 1960, and was purchased late that year by the present owner and co-operator, Mac Fetterley.

### GEOLOGY

The 27.6 m deep quarry is operated with two lifts, the lower of which is currently being used. The quarry exposes fine- to medium-crystalline, medium- to thick-bedded dolostones of the Oxford Formation. Thin calcite veins up to 5 cm thick trend across the quarry at 080° and dip 85° to the south. Glacial overburden around the quarry is up to 3 m thick. An excellent section of the quarry is illustrated in Hewitt (1960, p.21), and the quarry has not changed substantially since then.

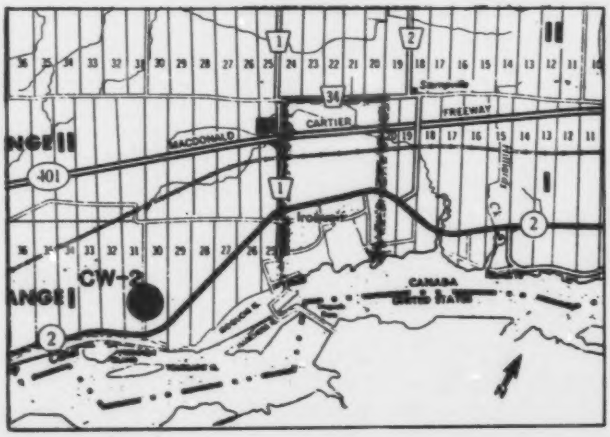


**Figure CW-2-1. LOCATION MAP FOR IROQUOIS QUARRY.**

Photo CW-2-1. PORTABLE CRUSHING/SCREENING PLANT AT IROQUOIS QUARRY (LOOKING NORTH-WEST).

### Geological Section

| | | *Thickness* |
|---|---|---|
| *UNIT 2* | *Oxford Formation* | *20.4m* |
| | Dolostone: medium to dark grey, weathers buff to light grey; fine to medium crystalline; medium to thick bedded (20–50 cm) with rare thin shale partings; large calcite-filled vugs occur in lowermost 5.5 m. | |
| *UNIT 1* | *Oxford Formation* | *7.2m* |
| | Dolostone: light grey, weathers buff to light grey; very fine to fine crystalline; medium to thick bedded (20–50 cm); large calcite- filled vugs present throughout unit. | |
| *Total thickness* | | *27.6m* |

### QUARRY OPERATION

The Iroquois Quarry has been excavated to a depth of approximately 27.6 m on two lifts, the lower of which is currently active. Drilling, blasting and processing is carried out under contract.

### PROCESSING

A Cat 980 loader is used to haul blasted stone to a Cedarapids 663 Commander crushing and screening plant and to stockpile finished products.

### PRODUCTS

Granular "A"
Granular "B"
Granular "C"
Screenings
7/8 in. Concrete Stone
5/8 in. Concrete Stone

### REFERENCES

Goudge, 1938, p. 57–59
Hewitt, 1960, p. 20–24
Hewitt, 1964a, p. 26
Hewitt and Vos, 1972, p. 10–11
Rogers, 1980, p. 71
Williams, in prep., Appendix 1 – Section LQ MO–3

### MAPS

Williams, Wolf and Carson, 1985b, OGS Map P.2722

## CW–3 CRUICKSHANK CONSTRUCTION LTD. — WILLIAMSBURGH QUARRY

### LOCATION AND OWNERSHIP

The Williamsburgh Quarry is located 13 km north of Morrisburg in Lot 31, Concession 7, Williamsburgh Township, Dundas County (Figure CW–3–1). The quarry was opened in 1969 and is owned and operated by Cruickshank Construction Ltd. The quarry licence covers an area of 6 ha.

### GEOLOGY

The 14.15 m deep quarry exposes interbedded limestones and dolostones of the lower member, Gull River Formation. Most of the dolostone contains some mud

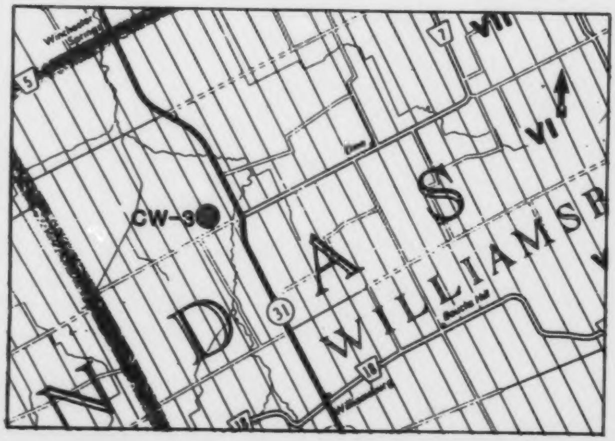


Figure CW-3-1. LOCATION MAP FOR WILLIAMSBURGH QUARRY.

and silt and is calcitic to some degree. The presence of a quartz sandstone bed suggests that the strata exposed in this quarry are near the base of the Gull River Formation. Glacial overburden around the quarry is generally 1–2 m thick.

### Geological Section

*Thickness*

*UNIT 5 Gull River Formation, lower member* *4.85m*

Silty dolostone interbedded with limestones: grey-brown to grey-green, weathers buff to grey-brown; dolostone: fine crystalline, limestones: microcrystalline to fine crystalline; thin to thick bedded with thin shale partings common between beds; calcite-filled vugs present; beds fracture conchoidally; intraclasts of light grey, microcrystalline limestone in some of the dolostone beds.

*UNIT 4 Gull River Formation, lower member* *0.2m*

Sandstone: light grey, weathers medium grey-gree[illegible]e- to coarse-grained, well-sorted, well-rounded quartz grains in a calcareous cement; scattered burrows.

*UNIT 3 Gull River Formation, lower member* *8.75m*

Silty dolostone, with interbeds of limestone: grey-brown to grey-green, weathers buff to red-brown; dolostone: fine crystalline, limestone: microcrystalline to very fine crystalline; thin to thick bedded; calcite- filled vugs present; conchoidal fractures common; intraclasts of light grey, microcrystalline limestone in some limestone beds; pyritized cephalopods present.

*UNIT 2 Gull River Formation, lower member* *0.25m*

Limestone: medium grey, weathers blue-grey to grey; oolitic; one bed; intraclasts of light grey, microcrystalline limestone present.

*UNIT 1 Gull River Formation, lower member* *0.1m*

Silty dolostone: grey-brown, weathers buff to red-brown; very fine to fine crystalline; one bed, with shale partings at top of unit; calcitic; scattered burrows.

*Total thickness* *14.15m*

### CHEMICAL ANALYSIS – Unit 5*

Components in Percent

| | | | |
|---|---|---|---|
| $SiO_2$ | 19.6 | CaO | 33.0 |
| $Al_2O_3$ | 3.75 | $P_2O_5$ | 0.04 |
| $Fe_2O_3$ | 1.27 | $SO_3$ | 0.90 |
| MgO | 6.51 | L.O.I. | 33.3 |
| | | Total | 98.4 |

**after Hewitt and Vos, 1972, p. 21.*

### QUARRY OPERATION

Overburden material has been placed in the quarry to provide two access ramps to the quarry floor and north blastface.

The excavated area of the quarry is about 2.8 ha, with two lifts. The quarry is currently advancing to the north on a single lift of 12.2 m. A Gardner–Denver 3100 air track and 750 cfm compressor are used to drill 7.6 cm diameter blast holes on a 2.1 m x 2.1 m pattern. AN/FO is used as a bulk explosive, initiated by electric caps – all blasts are monitored for vibration levels.

### PROCESSING

A portable crushing system is set up on-site when required and consists of a Cedarapids primary jaw crusher, a Cedarapids 855 Commander secondary crusher, and a Suntract 5 ft. x 14 ft. double-deck portable screen.

A Cat 988 loader is used to haul rock to the crusher and a Cat 966 is used to load trucks and handle stockpiles.

### PRODUCTS

Granular "A" and "B"
3/4 in. Clear Stone
–5/8 in. Screenings

### REFERENCES

Goudge, 1938, p. 58–59
Hewitt and Vos, 1972, p. 20–21
Williams, in prep., Appendix 1 – Section LQ WI–1

### MAPS

Williams, Wolf and Carson, 1985c, OGS Map P.2721

## CW–4 A.L. BLAIR CONSTRUCTION CO. LTD. — ST. ALBERT STATION QUARRY

### LOCATION AND OWNERSHIP

The St. Albert Station Quarry is located 1.5 km west of St. Albert Station in Lots 7 and 8, Concession 12, Finch Township, Stormont County (Figure CW–4–1). This quarry is the largest and oldest of the many quarries owned and operated by A. L. Blair Construction Co. Ltd. The quarry licence covers an area of about 80 ha.

The old Silvertone Black Marble Quarry described by Goudge (1938, p. 191–195), is located on the property. This historically significant quarry was a major source of building stone. Details of its geology and production follow the description of the St. Albert Station Quarry.

### GEOLOGY

The 14.9 m deep quarry exposes limestones of the lower and middle members of the Bobcaygeon Formation (Figure CW–4–2). The contact between the two members is placed where the thicker bedded, less shaly limestones of the lower member are overlain by thinner bedded, much more shaly limestones of the middle member. Glacial overburden around the quarry is up to 2 m thick.

**Photo CW-3-1. VIEW OF WILLIAMSBURGH QUARRY (LOOKING NORTHWEST).**

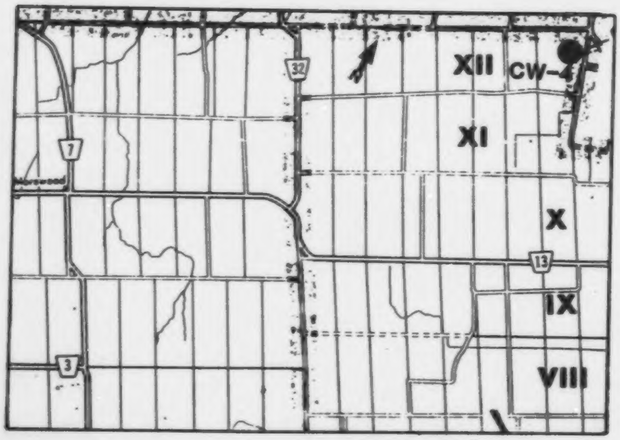


Figure CW-4-1. LOCATION MAP FOR ST. ALBERT STATION QUARRY.

## Geological Section

| | | *Thickness* |
|---|---|---|
| *UNIT 2* | *Bobcaygeon Formation, middle member* | *5.9m* |

Limestone: medium grey, weathers grey-brown; very fine to fine crystalline; thin to medium bedded, sharp contacts, commonly with dark grey shale partings; fossiliferous with abundant brachiopods and crinoids; top of lower lift at base of unit.

| | | |
|---|---|---|
| *UNIT 1* | *Bobcaygeon Formation, lower member* | *9.0m* |

Limestone: medium grey, weathers same; very fine crystalline; medium to thick bedded, contacts rarely have very thin dark grey shale partings; fossiliferous with abundant brachiopods.

*Total thickness* *14.9m*

## CHEMICAL ANALYSIS - Unit 2*

Components in Percent

| | | | |
|---|---|---|---|
| $SiO_2$ | 2.46 | CaO | 52.5 |
| $Al_2O_3$ | 0.66 | $P_2O_5$ | 0.02 |
| $Fe_2O_3$ | 0.44 | $SO_3$ | 0.53 |
| MgO | 1.37 | L.O.I. | 42.3 |
| | | Total | 100.3 |

* *after Hewitt and Vos, 1972, p.15.*

## QUARRY OPERATION

Two lifts of 5.9 m and 9.0 m have been excavated; the lower of which is currently being worked. There is also the potential for a third lift.

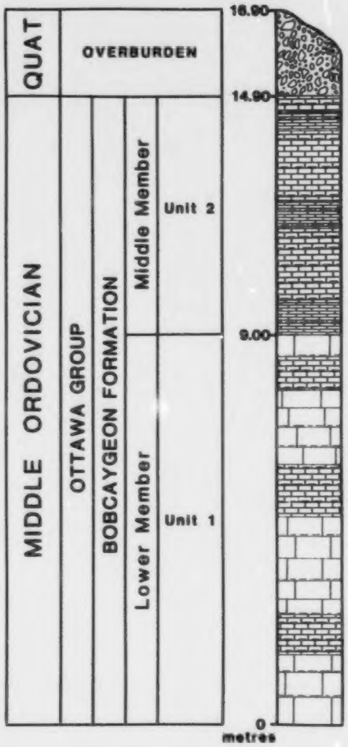


Figure CW-4-2. STRATIGRAPHIC COLUMN FOR ST. ALBERT STATION QUARRY.

A drilling pattern of 2.4 m x 2.4 m with 7.6 cm diameter holes is used. Approximately 20,000 tonnes is blasted ahead of crushing, which is carried out by a contractor.

## PROCESSING

A. L. Blair Construction owns three portable crushing plants, consisting of the following equipment.

### Primary Crushers

1 – Parker 24 in. x 36 in. Jaw
2 – Cedarapids 30 in. x 42 in. Double Impeller
1 – Cedarapids 22 in. x 48 in. Jaw
1 – Cedarapids 43 in. x 40 in. Impact

### Secondary Crushers

1 – 443 Cedarapids Commander
1 – 855 Cedarapids Commander
1 – Cedarapids 40 in. x 33 in. Hammer Mill

### Screening

1 – 5 ft. x 16 ft. Cedarapids Screening Plant
1 – 4 ft. x 12 ft. Cedarapids Screening Plant

### Heavy Equipment

3 – Terex 7261 61/2 yd. Loaders
2 – Hough International 90E 4 1/2 yd. Loaders
1 – Hough International 90C 4 1/2 yd. Loader
1 – Cat 966 4 1/2 yd. Loader
1 – 690B John Deere Backhoe
1 – Cat D7 Bulldozer
1 – Cat D5 Bulldozer
7 – Tandem Dump Trucks

## PRODUCTS

Granular "A" & "B" & "C"
3/4 in. Clear
1/2 in. Clear
3/8 in. Clear
Screenings
5/8 in. Concrete Stone
Agricultural Lime
Approved for HL products, though not currently being made.

## SILVERTONE BLACK MARBLE QUARRY

This abandoned dimension stone quarry lies adjacent to the active aggregate quarry. Although the quarry is not active, the steel derrick for removing blocks remains in place on the south side.

## GEOLOGY

Eighteen quarriable beds of black, microcrystalline to fine–crystalline limestone of the lower member, Bobcaygeon Formation, are exposed. A few beds are brownish–black, which would necessitate careful control to assure colour consistency. Scattered crystals of coarse, grey calcite impart an attractive silvery sheen to the polished surface. Beds range from 30 cm to 80 cm in thickness, but occasional thin shaly partings may cause planes of weakness in a few beds. The limestone is of high calcium composition and belongs to the lower member of the Bobcaygeon Formation.

## QUARRY OPERATION

The building stone quarry was operated from 1931 to 1957 and was worked on three lifts to a depth of 10 m. The quarry opening is 40 m by 25 m. Water now fills the lowest level. Overburden thickness is thin, but 1 m of thin–bedded limestone is removed from the top of the quarry section.

A regular pattern of vertical jointing in two directions at right angles facilitates the quarrying of large blocks. East–west jointing is spaced at 1.5 m to 3 m; north–

Photo CW-4-1. BOBCAYGEON FORMATION FORMERLY EXTRACTED FOR INTERIOR CLADDING; SILVERTONE BLACK MARBLE QUARRY.

south jointing at 4 m to 5 m. The stone was quarried by close drilling and broaching.

### PRODUCTS

The stone took an excellent polish and was highly prized for interior decorative purposes. According to M. F. Goudge (1938, p. 193) it was used in the following buildings: British Empire building, Rockefeller Centre, New York; Postal Terminal building and Notre Dame de Grace post office, Montreal; Ottawa Hydro Electric building, Postal Terminal building and the Justice building, Ottawa; Toronto Hydro Electric building and the T. Eaton Company store, Toronto; and in federal buildings in Hamilton, Guelph, Fort William, Winnipeg and Vancouver.

### REFERENCES

Goudge, 1938, p.191–195

Hewitt, 1964a, p.41

Hewitt and Vos, 1972, p.15

Williams, in prep., Appendix 1 – Section LQ WI–3

### MAPS

Williams, Wolf and Carson, 1985c, OGS Map P.2721

## CW–5 A.L. BLAIR CONSTRUCTION CO. LTD. — EMBRUN QUARRY

### LOCATION AND OWNERSHIP

The Embrun Quarry is located 1.0 km southeast of the village of Embrun in the north half of Lot 6 and the south half of Lot 7, Concession 8, Russell Township, Russell County (Figure CW–5–1). The quarry is owned and operated by A. L. Blair Construction Co. Ltd.

### GEOLOGY

The 12.0 m deep quarry exposes fine– to medium–crystalline, thin–bedded, shaly limestone of the middle member, Bobcaygeon Formation. Several minor faults can be seen in the quarry, trending between 070° and 110° with a southwest–side down displacement. Glacial overburden around the quarry is 1 to 2 m thick.

**Photo CW-5-1. GARDNER-DENVER AIR TRACK DRILLING BLAST HOLES AT EMBRUN QUARRY (LOOKING NORTHWEST).**

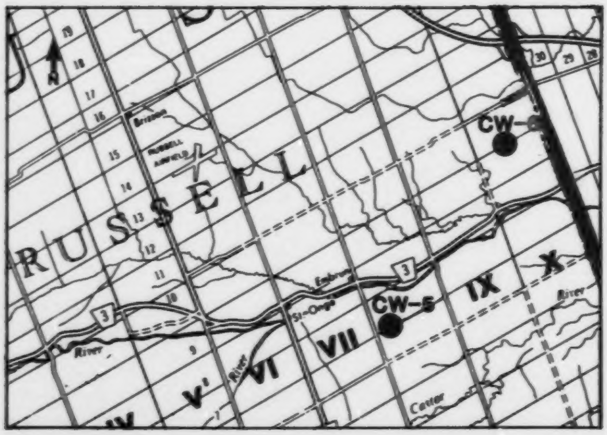

N
19
18
17
16
Brisson
RUSSELL AIRFIELD
15
14
13
12
11
10
9
RUSSELL
CW-6
CW-5
3
Embrun
St-Onge
River
River
River
Castor
IV
V
VI
VII
IX
X
30
29
28

**Figure CW-5-1. LOCATION MAP FOR EMBRUN QUARRY.**

### Geological Section

| | Thickness |
|---|---|
| *UNIT 1 Bobcaygeon Formation, middle member* | *12.0m* |
| Limestone: medium grey, weathers light grey; fine to medium crystalline, rarely coarse crystalline; thin bedded, rarely medium bedded, sharp, planar, and slightly undulating contacts, with shale partings common; calcite crystals are present in the coarse-crystalline beds; fossiliferous with abundant brachiopods, crinoidal debris, corals, gastropods, and bryozoans. | |
| *Total thickness* | *12.0m* |

### QUARRY OPERATION

Granular "A", "B" & "C" and 3/4 in. Clear were produced in 1986, from a single lift within the quarry.

### REFERENCES

Williams, in prep., Appendix 1 – Section LQ RU–5

### MAPS

Williams, Rae and Wolf, 1985c, OGS Map P.2717

## CW–6 DIBBLEE CONSTRUCTION CO. LTD. — LIMOGES QUARRY

### LOCATION AND OWNERSHIP

This quarry, located 5 km south of Limoges in Lot 9, Concession 10, Russell Township, Russell County, is intermittently operated by Dibblee Construction Co. Ltd (Figure CW-6-1).

### GEOLOGY

The 6.0 m deep quarry exposes limestone of the Lindsay Formation, lower member. The thin-bedded, nodular limestone is folded and contorted adjacent to a minor fault which trends at 120° and dips 70° to the southwest. The southwest side was downthrown only a few metres. Glacial overburden around the quarry is less than 1 m thick.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 1 Lindsay Formation, lower member* | *6.0m* |
| Limestone: medium to dark grey-brown, weathers blue-grey to brown; fine to medium crystalline; very thin to thin bedded, with shale interbeds up to 5 cm thick; weathering produces a nodular texture in upper part of quarry; fossiliferous with abundant brachiopods, crinoidal debris, gastropods, corals, and burrows. | |
| *Total thickness* | *6.0m* |

### REFERENCES

Williams, in prep., Appendix 1 – Section LQ RU-6

### MAPS

Williams, Rae and Wolf, 1985c, OGS Map P.2717

## CW-7 TOWNSHIP OF CLARENCE — CANAAN QUARRY

### LOCATION AND OWNERSHIP

The Canaan Quarry is located 4.5 km east of Sarsfield in Lot 11, Concession 11, Clarence Township, Russell County (Figure CW-7-1). The quarry was developed in 1950 by Clarence Township for road construction material and local commercial sales. The firm of McNeely Eng. Ltd. of Nepean has been retained since 1967 to manage production, contracting, product specifications and product inventory.

### GEOLOGY

The 17.0 m deep quarry exposes medium- to coarse-crystalline, thin-bedded, nodular limestone of the lower member of the Lindsay Formation in a single lift. The quarry has been developed southward into an east-west trending hillside. Glacial overburden around the quarry is 1-2 m thick.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 2 Lindsay Formation, lower member* | *2.0m* |
| Limestone: light to medium grey, weathers light brown; medium to coarse crystalline; thin bedded; nodular appearance. | |
| *UNIT 1 Lindsay Formation, lower member* | *15.0m* |
| Limestone: medium grey-brown, weathers light grey-brown; fine to coarse crystalline; thin to medium bedded with 1-2 cm thick shale partings between beds; fossiliferous with abundant gastropods, brachiopods, trilobites, crinoidal debris, and bryozoa. | |
| *Total thickness* | *17.0m* |

### QUARRY OPERATION

A single lift of about 17.0 m has been excavated over an area of approximately 350 m x 300 m (10.5 ha). The quarry will soon reach the property limits. Quarry drainage is assisted by a smooth and gently graded floor. A 4 in. submersible pump is used for dewatering of the quarry.

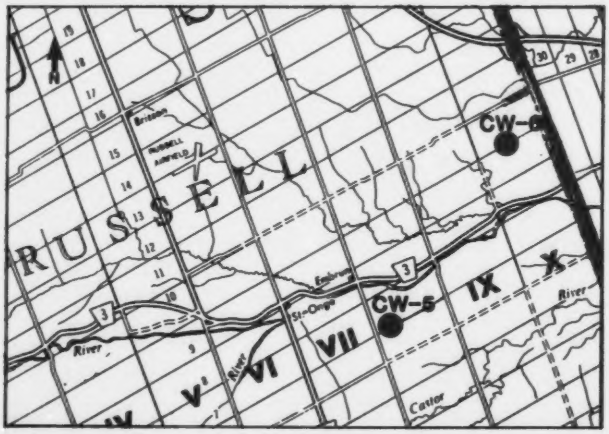


**Figure CW-6-1. LOCATION MAP FOR LIMOGES QUARRY.**

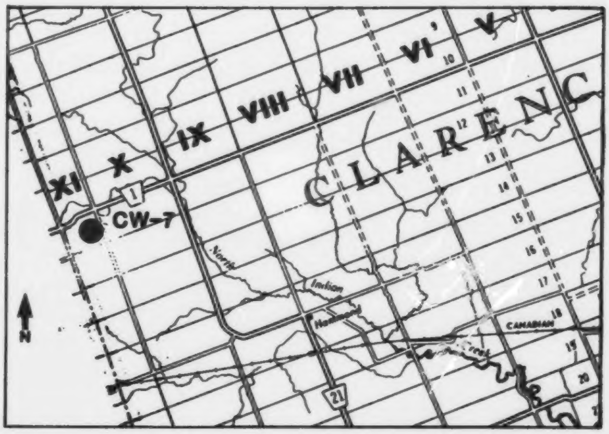


**Figure CW-7-1. LOCATION MAP FOR CANAAN QUARRY.**

Photo CW-7-1. SOUTHWEST QUARRY FACE, WITH DRILLING IN PROGRESS; CANAAN QUARRY.

## PROCESSING

Drilling and blasting is contracted and a 1.8 m x 1.8 m drill pattern is used with 3.8 cm diameter holes. Crushing is performed by portable systems. The quarry operates over a 9-month operating year, producing road base aggregates.

## REFERENCES

Hewitt, 1964a, p.40

Hewitt and Vos, 1972, p.17

Williams, in prep., Appendix 1 – Section LQ RU-2

## MAPS

Williams, Rae and Wolf, 1985c, OGS Map P.2717

# CW-8 ROCKLAND (STEWART) QUARRY

## LOCATION AND OWNERSHIP

This abandoned quarry, located 2.5 km south of the Town of Rockland, covers portions of Lots B and C, Concession 9, Clarence Township, Russell County (Figure CW-8-1). The quarry is not licensed under the Pits and Quarries Control Act.

## GEOLOGY

This long abandoned quarry has been included in this study as it displays a significant geological section of the Gull River and Bobcaygeon Formations. The two lifts expose 29.75 m of strata; silty dolostones and limestones of the lower member and thin-bedded shaly limestones of the upper member, Gull River Formation, overlain by thick bedded limestones of the lower member, Bobcaygeon Formation (Figure CW-8-2). The quarry was excavated into the face of an east-west escarpment which parallels the nearby Ottawa River. Glacial overburden at the escarpment's crest ranges from 1 to 4 m thick.

## Geological Section

*Thickness*

*UNIT 4 Bobcaygeon Formation, lower member 11.1m*

Limestone: medium to dark grey-brown, weathers blue-grey to grey-brown; microcrystalline to fine crystalline; thick to massive bedded, with rare thin to medium beds, some with thin, dark grey shale partings between them; rare nodular beds up to 30 cm thick.

*UNIT 3 Bobcaygeon Formation, lower member 8.4m*

Limestone: medium to dark grey-brown; weathers blue-grey to grey-brown; microcrystalline to fine crystalline; thick to massive bedded, with some very thin to thin beds, some of which have very thin shale partings; fossiliferous with abundant brachiopods, bryozoa, cephalopods, and gastropods; top of lower lift is at lower contact.

*UNIT 2 Gull River Formation, upper member 7.85m*

Limestone: medium grey-brown, weathers blue-grey; microcrystalline; very thin to thin bedded with thicker beds at base of unit, sharp and planar contacts, commonly with shale partings present; oolitic and intraclasts of limestone in the interval 1.5-2.35 m above base of unit; small calcite crystals, "birdseye" texture, very abundant in uppermost 5.5 m; fossiliferous, colonial coral, *Tetradium*, very abundant in upper 5.0 m of unit.

*UNIT 1 Gull River Formation, lower member 2.4m*

Limestone: with interbeds of silty dolostone (up to 80 cm thick); medium grey-brown; weathers blue-grey to grey-brown; limestones microcrystalline to fine crystalline, dolostones fine crystalline; very thin to medium bedded; most beds contain intraclasts of light grey limestone.

*Total thickness 29.75m*

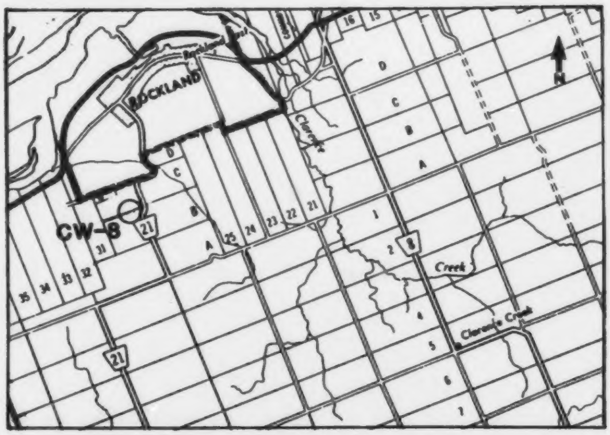


Figure CW-8-1. LOCATION MAP FOR ROCKLAND (STEWART) QUARRY.

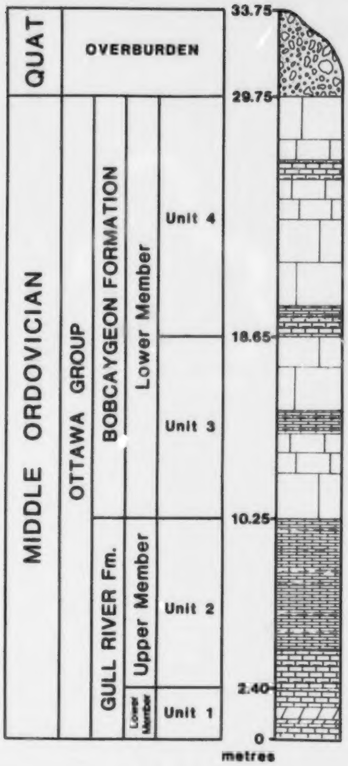

33.75
29.75
18.65
10.25
2.40
0
metres
QUAT
OVERBURDEN
MIDDLE ORDOVICIAN
OTTAWA GROUP
BOBCAYGEON FORMATION
Lower Member
Unit 4
Unit 3
GULL RIVER Fm.
Upper Member
Unit 2
Lower Member
Unit 1

Figure CW-8-2. STRATIGRAPHIC COLUMN FOR ROCKLAND (STEWART) QUARRY.

### REFERENCES

Goudge, 1938, p.180–182
Schoft, 1966
Barnes, 1967
Barnes, 1968, p.170
Williams, in prep., Appendix 1 – Section AQ TH–1

### MAPS

Williams, Rae and Wolf, 1985c, OGS Map P.2717

## CW-9 CORNWALL GRAVEL COMPANY LTD. — RICHIER QUARRY

### LOCATION AND OWNERSHIP

The Richier Quarry is located at Mayerville, 5 km south of Casselman, in Lot 10, Concession 10, Cambridge Township, Russell County (Figure CW–9–1). The quarry was first opened on a commercial basis in 1983 by the owner and operator Cornwall Gravel Company Ltd.

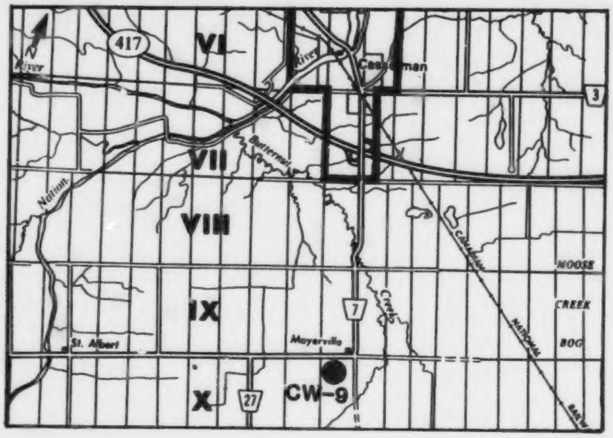

417
VI
River
Casselman
3
VII
Butternut
Nation
VIII
IX
7
St. Albert
Mayerville
CW-9
X
27
Creek
Canadian National
MOOSE
CREEK
BOG

Figure CW-9-1. LOCATION MAP FOR RICHIER QUARRY.

Photo CW-9-1. WEST FACE OF RICHIER QUARRY WITH LOAD OUT FROM STOCKPILES.

### GEOLOGY

The 12.7 m deep quarry exposes fine– to medium–crystalline, thin–bedded, nodular limestone of the lower member, Lindsay Formation. Water once filling the quarry has only recently been pumped out; the limestone that is now exposed is almost white in colour. Glacial overburden around the quarry is less than 1 m thick.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 1 Lindsay Formation, lower member* | *12.7m* |
| Limestone: medium grey, weathers dark grey (light grey where once under water); fine to medium crystalline with some coarse-grained bioclastic beds; medium bedded (10-20 cm), regular, sharp contacts, with thin (1 cm) shale partings producing a faint nodular texture in places; fossiliferous, with abundant crinoidal debris and brachiopods, and burrows are also common. | |
| *Total thickness* | *12.7m* |

### QUARRY OPERATION

The Richier Quarry is mined to a depth of 12.7 m on two lifts over an area of approximately 1.5 ha. The stone is quarried by drilling and blasting.

### PROCESSING

A portable crusher system is used at the site. Rock is hauled by Michigan 275 6.5 yd. loader to a 43 in. x 40 in. Cedarapids impeller primary crusher and then screened by an 8 ft. x 20 ft. Pioneer screening plant producing Granular "A" and oversize that is sent to a Cedarapids 855 Commander jaw and roller secondary crusher. Stone leaving the secondary crusher is screened by a Suntract 6 ft. x 16 ft. portable screen, producing weeping tile stone, HL3, HL4 and dust.

The quarry stone possesses relatively low silica content (2%), and is principally used for road base and asphalt. No tests have been made to date to determine potential concrete stone applications.

### Products

Granular "A" and "B"
1 in. Clear
Weeping Tile Stone
HL3, HL4
Dust

### REFERENCES

None

### MAPS

Williams, Rae and Wolf, 1985c, OGS Map P.2717

## CW-10 A.L. BLAIR CONSTRUCTION CO. LTD. — McLEAN (FINCH) QUARRY

### LOCATION AND OWNERSHIP

The McLean Quarry is located 2 km southwest of Finch in Lot 11, Concession 2, Finch Township, Stormont County (Figure CW-10-1). The property is licensed for an area of approximately 2 ha. The quarry has been opened on a single lift of 4.0 m and is operated intermittently by A. L. Blair Construction Co. Ltd.

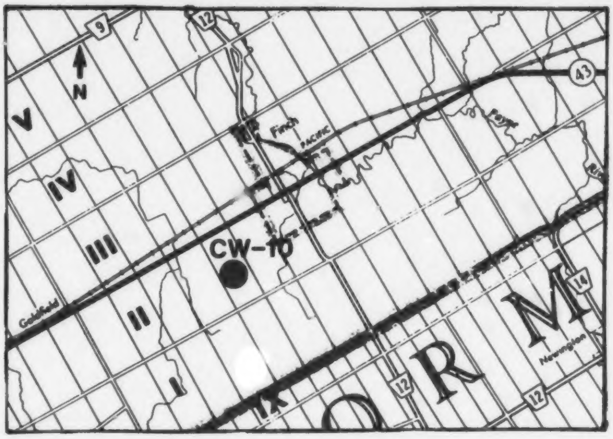


Figure CW-10-1. LOCATION MAP FOR McLEAN (FINCH) QUARRY.

### GEOLOGY

The 4.0 m deep quarry exposes interbedded limestones and shales of the Verulam Formation. The fine- to coarse-crystalline, thin-bedded limestones alternate with very thin-bedded shale. Glacial overburden around the quarry is 1-2 m thick.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 1 Verulam Formation* | *4.0m* |
| Limestone, interbedded with shale: medium grey, weathers light to medium grey; fine to coarse crystalline; limestones are thin bedded (7-10 cm), shales are very thin bedded (2-4 cm), sharp and planar contacts; some coarse crystalline beds are bioclastic and calcarenitic; fossiliferous with abundant brachiopods, crinoidal debris, and trilobites (mainly fragments), burrows are abundant on bedding planes. | |
| *Total thickness* | *4.0m* |

### REFERENCES

None

### MAPS

None

## CW-11 A.L. BLAIR CONSTRUCTION CO. LTD. — PLUMADORE QUARRY

### LOCATION AND OWNERSHIP

The Plumadore Quarry is located in Lot 27, Concession 5, Osnabruck Township, Cornwall County (Figure CW-11-1). The quarry was opened in 1979 by the present owner and operator, A. L. Blair Construction Co. Ltd. Immediately to the west is a second quarry operated by Osnabruck Township.

## GEOLOGY

The two quarries were both partially flooded at the time of the site visit. Above the water level 3.0 m of thin-bedded shaly limestone of the Verulam Formation was visible in both quarries. Glacial overburden around the quarries is less than 0.5 m thick.

### Geological Section

| | | *Thickness* |
|---|---|---|
| *UNIT 1* | *Verulam Formation* | *3.0m* |
| | Limestone, with shale partings: light to dark grey-brown, weathers blue- grey to brown; very fine to medium crystalline; thin to medium bedded, with shale partings up to 2 cm thick; fossiliferous, with abundant brachiopods, bryozoa, and crinoidal debris. | |
| *Total thickness* | | *3.0m* |

## QUARRY OPERATION

The Plumadore Quarry had been excavated by drilling and blasting on two lifts of 6.1 m each. The quarry was filled with water in 1986.

## PROCESSING

The quarried stone is delivered to a portable crushing and screening plant for processing.

## PRODUCTS

The primary product is granular road base and is produced on demand for local road construction projects.

## REFERENCES

Williams, in prep., Appendix 1 – Section LQ WI–4

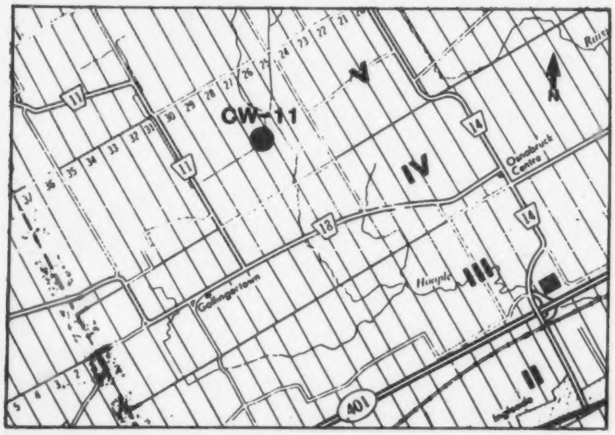


**Figure CW-11-1. LOCATION MAP FOR PLUMADORE QUARRY.**

## MAPS

Williams, Wolf and Carson, 1985c, OGS Map P.2721

# CW-12 PERMANENT CONCRETE – CORNWALL QUARRY

## LOCATION AND OWNERSHIP

The Cornwall Quarry of Permanent Concrete is located approximately 6 km northwest of Cornwall, in Lots 25–29, Concession 4, Cornwall Township, Stormont County (Figure CW–12–1).

Stone blocks were removed from the property during the 1880s for the initial construction of the Cornwall Canal. The present quarry was opened in 1968 by Permanent Concrete, now a division of Canfarge Ltd., and supplies crushed stone for construction projects.

## GEOLOGY

The 24.8 m deep quarry exposes a section from the lower member of the Gull River Formation to the lower member of the Bobcaygeon Formation (Figure CW–12–2). The lower part of the quarry exposes interbedded microcrystalline limestones and fine–crystalline dolostones of the lower member, Gull River Formation. The overlying very fine–crystalline, thin–bedded shaly limestones of the upper member are, in turn, overlain by the microcrystalline to fine–crystalline, thick–bedded limestones of the lower member, Bobcaygeon Formation. The three lift levels of the quarry correspond to each member. Glacial overburden around the quarry is 1 to 3 m thick.

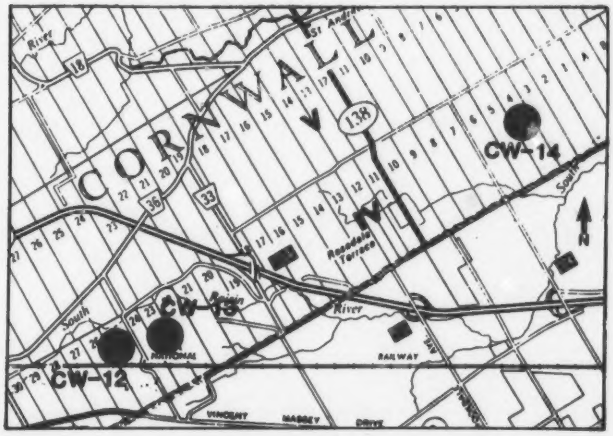


**Figure CW-12-1. LOCATION MAP FOR CORNWALL QUARRY.**

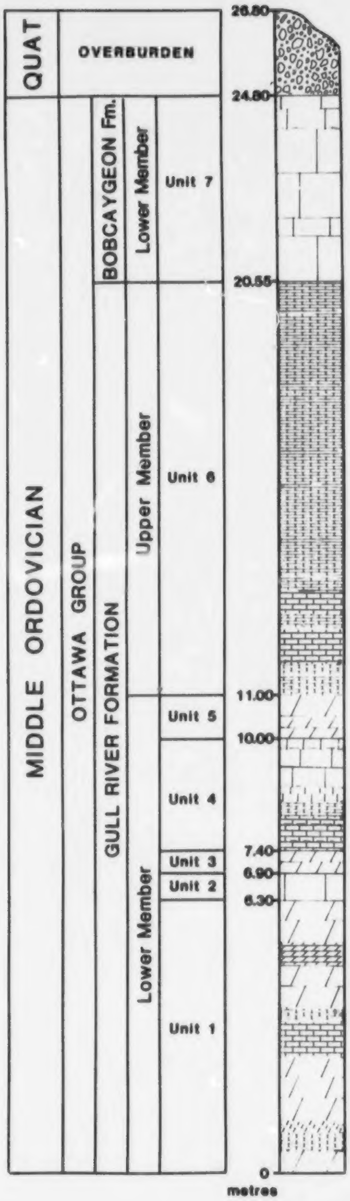


Figure CW-12-2. STRATIGRAPHIC COLUMN FOR CORNWALL QUARRY.

## Geological Section

| | Thickness |
|---|---|
| *UNIT 7 Bobcaygeon Formation, lower member* | *4.3m* |

Limestone: medium to dark brown, weathers blue-grey; microcrystalline to fine crystalline; thick to massive bedded, with rare, very thin shale partings; top of 2nd lift at base of unit.

| | |
|---|---|
| *UNIT 6 Gull River Formation, upper member* | *9.5m* |

Limestone, with shale partings: medium to dark grey-brown, weathers blue-grey to brown; microcrystalline to fine crystalline; very thin to thin bedded, with thicker beds occurring in the lower part of the unit; beds containing intraclasts of limestone common; top of 1st (lower) lift at base of unit.

| | |
|---|---|
| *UNIT 5 Gull River Formation, lower member* | *1.0m* |

Dolostone: light grey-green, weathers buff to red-brown; microcrystalline to fine crystalline, portions of unit may contain mud and silt; medium to thick bedded; some beds contain intraclasts of limestone; calcite and pyrite mineralization common; vugs commonly filled with calcite crystals.

| | |
|---|---|
| *UNIT 4 Gull River Formation, lower member* | *2.6m* |

Limestone, with shale partings: medium to dark grey-brown; weathers blue-grey to brown; microcrystalline to fine crystalline; thin to thick bedded, with thin shale partings; intraclasts of limestone common.

| | |
|---|---|
| *UNIT 3 Gull River Formation, lower member* | *0.5m* |

Dolostone: light grey-green, weathers buff to red-brown; microcrystalline to fine crystalline; single bed; contains intraclasts of limestone.

| | |
|---|---|
| *UNIT 2 Gull River Formation, lower member* | *0.6m* |

Limestone: dark grey, weathers blue-grey to dark grey; single bed of oolitic limestone which contains intraclasts of light grey limestone.

| | |
|---|---|
| *UNIT 1 Gull River Formation, lower member* | *6.3m* |

Dolostone, interbedded with limestone, shaly limestone and shaly dolostone:

limestone – medium grey, weathers light grey; microcrystalline to very fine crystalline; medium bedded; small calcite patches rare; oolitic and intraclastic limestone in lowermost 30 cm of unit;

dolostone – light grey to grey-green, weathers light grey-green; very fine to fine crystalline; thick bedded; small calcite patches common;

shaly limestones and dolostones – typically dark grey and light green, respectively; very thin to thin bedded; contacts are generally sharp and planar.

| | |
|---|---|
| *Total thickness* | *24.8m* |

## CHEMICAL ANALYSES*

| | Components in Percent | |
|---|---|---|
| | Unit 7 | Unit 6 |
| $SiO_2$ | 1.01 | 6.34 |
| $Al_2O_3$ | 0.95 | 3.33 |
| $Fe_2O_3$ | 0.60 | 1.08 |
| MgO | 0.91 | 1.47 |
| CaO | 53.5 | 48.3 |
| L.O.I. | 43.0 | 38.6 |
| Total | 99.97 | 99.12 |
| $CO_2$ | 42.0 | 38.9 |

* *after Hewitt and Vos, 1972, p.37.*

Photo CW-12-1. LOWER LIFT OF THE WEST FACE OF CORNWALL QUARRY.

### QUARRY OPERATION

Most of the overburden is removed by a Cat 980C 5-yd. loader; a backhoe with Gradall bucket is used to clean down to the rock surface. The quarry is mined on three lifts of 4.3 m, 9.5 m, and 11.0 m. The first lift primarily supplies concrete stone, the second lift HL and granular stone products, and the third lift produces solely granular stone.

Drilling and blasting is by contract. A drill pattern of 2.1 m x 2.1 m with 7.6 cm diameter holes is used on the first lift while a 2.4 m x 2.4 m pattern is used on the second and third lifts.

### PROCESSING

Blasted stone is loaded by a Cat 980C loader to Euclid trucks and hauled approximately 150 m to the primary surge hopper. Minus 5/8 in. material is scalped by a vibrating screen and stockpiled. Oversize stone passes to a Cedarapids 36 in. x 45 in. impactor for primary crushing and is then sent to the "centre screen" (single deck), which can be set to size at –4 in. or –2 in., depending on the desired products. Oversize from the screen is returned to the primary crusher, while undersize stone is sent to the screening tower for separation by two 5 ft. x 12 ft. triple-deck Tyler screens producing 1/4 in. fines, 3/8 in. chips, 3/4 in. clear and –2 in. +3/4 in. sizings. These products are stored in four hoppers. The oversize product can be returned by 30 in. conveyor to the primary crusher, which is equipped with a surge bin.

### PRODUCTS

Granular "A", "B" and "C"
3/4 in. Clear
3/8 in. Clear
Screenings
HL3, HL4 and HL8

### REFERENCES

Goudge, 1938, p.194
Hewitt and Vos, 1972, p.37
Williams, in prep., Appendix 1 – Section LQ CO-2

### MAPS

Williams, Wolf and Carson, 1985a, OGS Map P.2720

## CW-13 DIBBLEE CONSTRUCTION CO. LTD. — CORNWALL QUARRY

### LOCATION AND OWNERSHIP

This quarry, located 6 km northwest of Cornwall in Lot 23, Concession 4, Cornwall Township, Stormont County (Figure CW–13–1), is intermittently operated by the Dibblee Construction Co. Ltd., part of the Warren Paving and Materials Group Ltd. This quarry is located east of the Cornwall Quarry of Permanent Concrete Ltd. (CW–12).

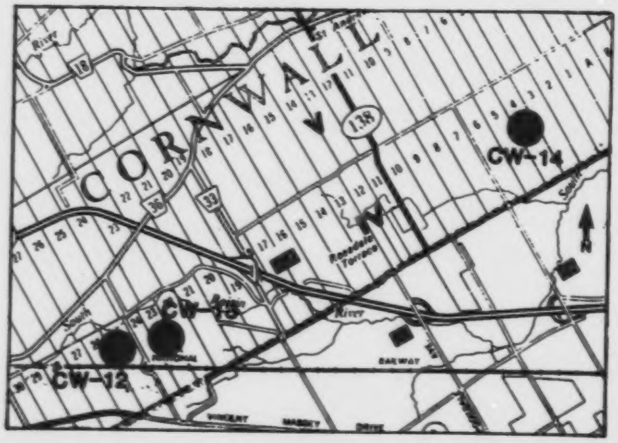


Figure CW-13-1. LOCATION MAP FOR CORNWALL QUARRY.

### GEOLOGY

The old, original quarry on the Dibblee property is partially flooded, with approximately 2 m of limestone exposed above the water level. A recently excavated extension southward of the old quarry provided a section of 9.7 m. Thin-bedded, microcrystalline, shaly limestones of the upper member, Gull River Formation are overlain by the microcrystalline to fine-crystalline, thick-bedded limestones of the lower member of the Bobcaygeon Formation. Glacial overburden around the quarry ranges from 1 to 4 m in thickness.

### Geological Section

| | | *Thickness* |
|---|---|---|
| *UNIT 4* | *Bobcaygeon Formation, lower member* | *3.0m* |

Limestone: medium to dark grey, weathers very light grey; very fine to fine crystalline, becomes medium crystalline (calcarenitic) at the top; massive bedded (1.0-1.5 m), with stylolitic contacts; calcite replaces fossils; abundant brachiopods; lower contact of unit sharp and slightly irregular.

| | | |
|---|---|---|
| *UNIT 3* | *Gull River Formation, upper member* | *1.6m* |

Limestone: light to medium grey, weathers light grey- brown; microcrystalline to very fine crystalline; medium bedded with sharp, planar contacts, either shaly or stylolitic with the number of stylolites increasing upwards; abundant, small calcite crystals, "birdseye" texture, with rare larger crystals; sparsely fossiliferous, with rare brachiopods; on joint planes bedding appears thicker (30 to 50 cm).

| | | |
|---|---|---|
| *UNIT 2* | *Gull River Formation, upper member* | *2.0m* |

Limestone: light to medium grey, weathers light grey- brown; microcrystalline to very fine crystalline; thin to medium bedded, with sharp stylolitic contacts; "birdseye" texture is common; lower contact of unit sharp and planar.

| | | |
|---|---|---|
| *UNIT 1* | *Gull River Formation, upper member* | *3.1m* |

Limestone: light medium grey, weathers medium grey; microcrystalline to very fine crystalline; medium bedded with sharp, planar contacts, either shaly or stylolitic with the number of stylolites increasing upwards; abundant, small calcite crystals, "birdseye" texture, with rare larger crystals; sparsely fossiliferous, with rare brachiopods; on joint planes bedding appears thicker bedded (30 to 50 cm).

| | |
|---|---|
| *Total thickness* | *9.7m* |

### REFERENCES

Goudge, 1938, p.194-196
Hewitt, 1964a, p.42
Hewitt and Vos, 1972, p.22
Williams, in prep., Appendix 1 - Section LQ CO-3

### MAPS

Williams, Wolf and Carson, 1985a, OGS Map P.2720

## CW-14 CORNWALL GRAVEL COMPANY LTD. — MacLEOD QUARRY

### LOCATION AND OWNERSHIP

The MacLeod Quarry is located about 5 km north of Cornwall in Lots 3-5, Concession 4, Cornwall Township, Stormont County (Figure CW-14-1). Stone blocks were first removed from the MacLeod Quarry during the 1880s for use in the initial construction of the Cornwall Canal. In 1959 the quarry was opened by the present owner and operator, Cornwall Gravel Company Ltd.

### GEOLOGY

The 33.4 m deep quarry exposes strata of the lower and upper members of the Gull River Formation, and of the lower member of the Bobcaygeon Formation (Figure CW-14-2). The lower member, Gull River Formation consists of fine-crystalline, medium-bedded dolostones which are interbedded with microcrystalline to fine-crystalline, medium-bedded limestones. The upper member consists of microcrystalline to very fine-crystalline, thin-bedded limestone which is interbedded with thin, dark grey shale beds. The lower member of the Bobcaygeon Formation consists of microcrystalline to fine-crystalline, thick- to massive-bedded limestone. Overburden ranges from 2.4 m to 7.6 m in thickness.

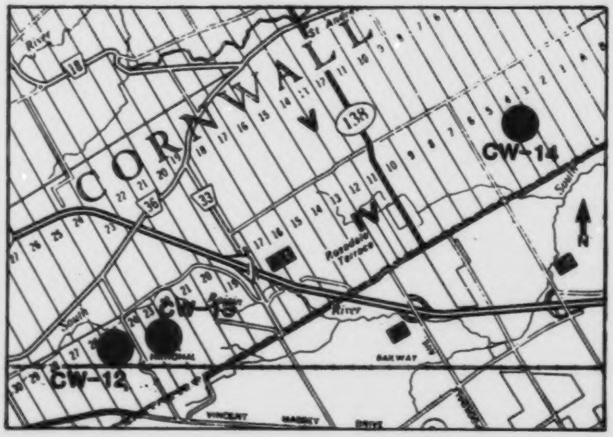


**Figure CW-14-1. LOCATION MAP FOR MacLEOD QUARRY.**

## Geological Section

*Thickness*

*UNIT 19 Bobcaygeon Formation, lower member 4.4m*

Limestone: medium to dark grey-brown, weathers blue-grey to medium grey; microcrystalline to fine crystalline; thick to massive bedded; lower contact of unit sharp and planar; top of 2nd lift at base of unit.

*UNIT 18 Gull River Formation, upper member 1.8m*

Limestone: medium to dark grey-brown, weathers light blue-grey to medium grey; microcrystalline; very thin to thin bedded, with thin shale partings common between beds; lower contact of unit sharp.

*UNIT 17 Gull River Formation, upper member 7.1m*

Limestone: medium to dark grey-brown, weathers light blue-grey to medium grey; microcrystalline; very thin to rarely thick bedded, with shale partings (1 cm thick) common between beds; intraclasts of light grey limestone abundant; small calcite crystals, "birdseye" texture in some beds; fossiliferous, with abundant crinoidal debris, brachiopods, bryozoans, and abundant colonial corals (*Tetradium*); lower contact of unit sharp and slightly irregular; top of 3rd lift is at base of unit.

*UNIT 16 Gull River Formation, lower member 1.1m*

Dolostone: light grey-green to medium grey-brown, weathers buff to red-brown; microcrystalline to fine crystalline, with significant amounts of mud and silt in some beds; medium to thick bedded; intraclasts of limestone present; calcite-filled vugs present; lower contact of unit sharp.

*UNIT 15 Gull River Formation, lower member 1.0m*

Limestone: medium to dark grey-brown, weathers light blue-grey to medium grey; microcrystalline to fine crystalline; thin to thick bedded, with thin shale partings between some beds; intraclasts of limestone common; lower contact of unit sharp and planar.

*UNIT 14 Gull River Formation, lower member 0.8m*

Dolostone: light grey-green to medium grey-brown, weathers buff to red-brown; microcrystalline to fine crystalline, may contain some mud and silt; medium to thick bedded; lower contact of unit sharp.

*UNIT 13 Gull River Formation, lower member 0.8m*

Limestone: dark grey, weathers blue-grey to dark grey; oolitic in a fine crystalline matrix; thick bedded; intraclasts of light grey limestone present; lower contact is sharp and undulatory.

*UNIT 12 Gull River Formation, lower member 5.2m*

Limestone: dark grey, weathers medium grey; microcrystalline to very fine crystalline; thin to medium bedded, sharp and planar contacts, with few thin shale limestone partings; pyrite crystals are common, as are very small calcite patches; fossiliferous with abundant ostracods present in some beds; lower contact of unit sharp and planar; top of 4th lift at base of unit.

*UNIT 11 Gull River Formation, lower member 2.6m*

Limestone: dark grey, weathers medium grey; microcrystalline to very fine crystalline; medium bedded, with sharp and planar contacts; beds are poorly defined; pyrite patches are common, large calcite-filled vugs in upper 20 cm; lower contact of unit is sharp and planar.

*UNIT 10 Gull River Formation, lower member 1.4m*

Limestone, with some dolomitic mottles: light to medium grey, weathers medium grey; microcrystalline to very fine crystalline; medium bedded, sharp, planar to slightly irregular contacts; abundant, large (10-15 cm) calcite-filled vugs and patches, pyrite patches also common; lower contact of unit is sharp and irregular.

*UNIT 9 Gull River Formation, lower member 0.3m*

Dolostone: light green, weathers same; fine crystalline; medium to thick bedded; this unit is only visible where there is no talus; lower contact of unit sharp and planar; top of 5th lift at base of unit.

*UNIT 8 Gull River Formation, lower member 1.1m*

Dolostone: light green, weathers light grey-green; very fine to fine crystalline; thick bedded, with sharp and planar contacts; calcite- filled vugs very abundant in lower 50 cm; 15 cm thick, medium grey, microcrystalline limestone bed 0.5 m above base of unit; lower contact of unit sharp, slightly irregular, and stylolitic.

*UNIT 7 Gull River Formation, lower member 0.3m*

Limestone: dark grey, weathers medium grey; microcrystalline to very fine crystalline; medium bedded; lower contact of unit sharp and slightly irregular.

*UNIT 6 Gull River Formation, lower member 0.7m*

Dolostone: light green to light grey-green, weathers light grey-green; very fine crystalline; thick bedded; small calcite-filled vugs present; lower contact of unit sharp and planar.

*UNIT 5 Gull River Formation, lower member 0.6m*

Limestone: dark grey, weathers medium grey; microcrystalline; thick bedded; lower contact of unit sharp and slightly irregular.

*UNIT 4 Gull River Formation, lower member 0.4m*

Dolostone: light green, weathers light grey-green; fine crystalline; medium bedded; contains some silt and mud; lower contact of unit sharp and planar.

*UNIT 3 Gull River Formation, lower member 0.8m*

Limestone: dark grey, weathers medium grey; microcrystalline to very fine crystalline; very thin to thin bedded, with sharp, undulatory contacts, with very thin dark grey shale partings; lower contact of unit sharp and planar.

*UNIT 2 Gull River Formation, lower member 0.6m*

Sandy dolostone: light green, weathers light grey-green; coarse- to very coarse-grained quartz sand grains in a fine-crystalline dolostone; single, thick bed; lower contact of unit sharp, planar and in places welded.

*UNIT 1 Gull River Formation, lower member 2.4m*

Limestone: medium to dark grey, weathers medium grey; microcrystalline to very fine crystalline; medium to thick bedded, contacts are sharp and planar; small calcite patches present.

*Total thickness 33.4m*

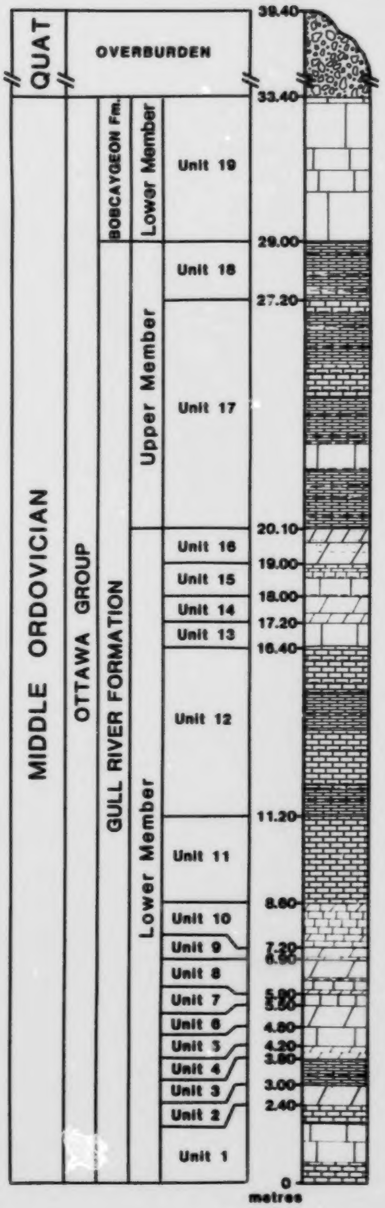

QUAT
OVERBURDEN
MIDDLE ORDOVICIAN
OTTAWA GROUP
BOBCAYGEON Fm.
GULL RIVER FORMATION
Lower Member
Upper Member
Lower Member
Unit 19
Unit 18
Unit 17
Unit 16
Unit 15
Unit 14
Unit 13
Unit 12
Unit 11
Unit 10
Unit 9
Unit 8
Unit 7
Unit 6
Unit 5
Unit 4
Unit 3
Unit 2
Unit 1
39.40
33.40
29.00
27.20
20.10
19.00
18.00
17.20
16.40
11.20
8.60
7.20
6.90
5.90
5.50
4.80
4.20
3.80
3.00
2.40
0
metres

Figure CW-14-2. STRATIGRAPHIC COLUMN FOR MacLEOD QUARRY.

## CHEMICAL ANALYSES*

| | Components in Percent | | |
|---|---|---|---|
| | Units 18-19 | Unit 17 | Units 13-16 |
| $SiO_2$ | 5.63 | 9.33 | 15.0 |
| $Al_2O_3$ | 1.75 | 2.12 | 3.25 |
| $Fe_2O_3$ | 0.72 | 1.02 | 1.13 |
| MgO | 1.10 | 1.52 | 3.70 |
| CaO | 49.3 | 46.6 | 40.0 |
| $P_2O_5$ | 0.01 | 0.02 | 0.02 |
| $SO_3$ | 0.98 | 0.98 | 0.43 |
| L.O.I. | 39.9 | 38.0 | 35.4 |
| Total | 99.4 | 99.6 | 98.9 |

* *after Hewitt and Vos, 1972, p.20.*

## QUARRY OPERATION

The quarry is presently excavated on five lifts of approximately 4.4 m, 8.9 m, 8.9 m, 4.3 m, 6.9 m in height. The first and second lifts supply clear and concrete stone products. The following design changes are presently being considered at the MacLeod Quarry:

(1) Grouping first and second lifts as a single lift.

(2) Grouping third, fourth and fifth lifts as a single lift.

(3) Increase blast fragmentation by tightening the drilling pattern to 2.1 m x 2.1 m, with 6.4 cm diameter blast holes.

Overburden is removed during the winter when the crushing operation is discontinued for maintenance and repair work.

## PROCESSING

The crushing and screening plant can be adapted to produce a variety of finished materials according to the screen sizings used and flow path set. One example is used below.

The blasted stone is loaded by two, 6 1/2 yd. Michigan 275 loaders into four, 35-ton Wabco trucks and hauled approximately 500 m to a permanent 43 in. x 50 in. Cedarapids double-impeller primary crusher. Fine material is scalped and bypasses the crusher. Crushed stone and the scalped fines are screened by a double-deck 6 ft. x 16 ft. scalping screen producing -7/8 in. material (Granular "A") for bin storage and oversize to a 30 in. x 30 in. Cedarapids double-impeller secondary crusher. The stone then passes to a 5 ft. x 16 ft. triple-deck Nordberg vibratory screen, from which an undersize product (HL3) goes to bin storage, and oversize to a 5 ft. x 14 ft. Cedarapids screen. The Cedarapids screen produces a 5/8 in. clear stone and an oversize to a 42 in. Pulvamatic cage crusher. Stone leaving the Pulvamatic crusher returns in closed circuit to the 5 ft. x 14 ft. Cedarapids screen. Three Euclid 22-ton trucks are used for stockpiling finished products at the plant.

Photo CW-14-1. VIEW OF MacLEOD QUARRY (LOOKING SOUTHEAST).

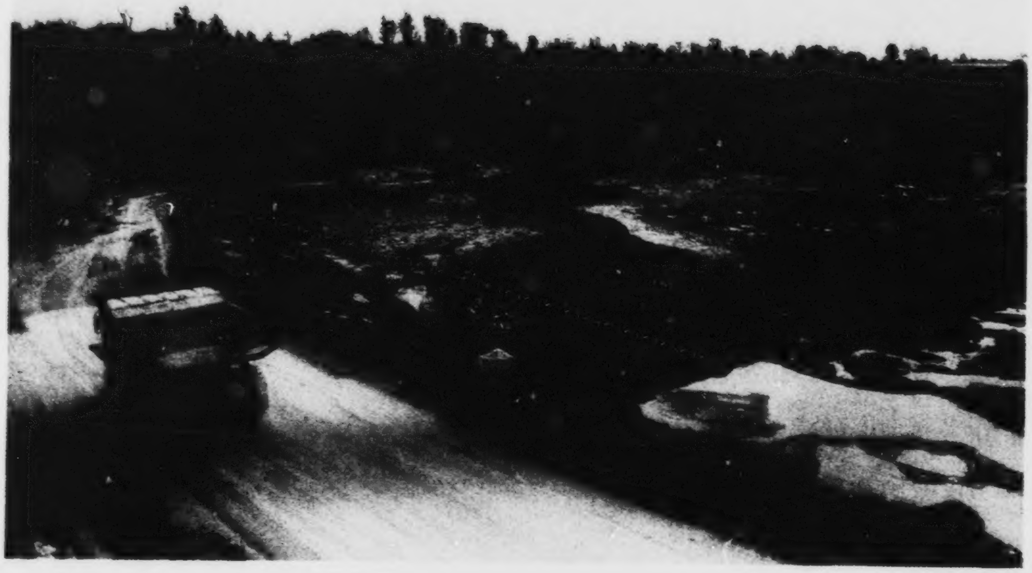


Photo CW-14-2. PROCESSING PLANT (LOOKING SOUTH); MacLEOD QUARRY.

## PRODUCTS

- 2 in. to 4 in. Quarry Stone
- Granular "A", "B" and "C"
- 1 1/2 in. Field Bed Stone
- 1 in. Clear
- 3/4 in. Clear
- 5/8 in. Clear
- 1/2 in. Clear
- 3/8 in. Clear
- Masonry Sand
- Sand
- Stone Dust

## REFERENCES

Goudge, 1938, p.195-196
Hewitt, 1964a, p.42
Hewitt and Vos, 1972, p.20
Williams, in prep., Appendix 1 - Section LQ CO-1

## MAPS

Williams, Wolf and Carson, 1985a, OGS Map P.2720

## CW-15 A.L. BLAIR CONSTRUCTION CO. LTD. — CHRISTIE QUARRY

### LOCATION AND OWNERSHIP

The Christie Quarry is located 5 km south of the hamlet of Apple Hill in Lot 12, Concession 9, Charlottenburgh Township, Glengarry County (Figure CW-15-1) and is licensed for 60.7 ha. The quarry was opened in 1983 by the owner and operator A. L. Blair Construction Co. Ltd. and the excavated area is now approximately 1 ha. The property was first used to provide building stone for local uses but is now intermittently operated on a single lift of 7.3 m for aggregates.

### GEOLOGY

The quarry exposes 4.5 m of very fine- to fine-crystalline, thin-bedded, nodular limestones of the lower member of the Lindsay Formation. During field work in 1986 the quarry was partially filled with water. Glacial overburden around the quarry is less than 0.5 m thick.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 1 Lindsay Formation, lower member* | *4.5m* |
| Limestone: medium to dark grey, weathers medium grey to grey-brown; very fine to fine crystalline; thin to medium bedded (5-20 cm), sharp contacts with some thin shale partings, weathers into nodular texture in uppermost 2 m; fossiliferous with abundant brachiopods and crinoidal debris. | |
| *Total thickness (exposed in 1986)* | *4.5m* |

### PRODUCTS

Granular "A" and "B"
3/4 in. Tile Stone
Screenings
MTO approved for HL products

### REFERENCES

None

### MAPS

None

## CW-16 A.L. BLAIR CONSTRUCTION CO. LTD. — GRAVEL HILL QUARRY

### LOCATION AND OWNERSHIP

This quarry is located 1.5 km northeast of the hamlet of Gravel Hill in Lot 9, Concession 4, Roxborough Township, Stormont County (Figure CW-16-1). The property is licensed for an approximate area of 4 ha. The quarry presently covers an area of about 1 ha.

### GEOLOGY

The 4.2 m deep quarry exposes fine- to medium-crystalline, thin-bedded, nodular limestone of the lower member of the Lindsay Formation. Glacial overburden around the quarry is less than 1 m thick.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 1 Lindsay Formation, lower member* | *4.2m* |
| Limestone: light to dark grey-brown, weathers blue- grey to brown; most beds very fine crystalline with some medium crystalline beds; very thin to rare thick bedded, with thin, irregular shale partings common between most beds; nodular texture in places. | |
| *Total thickness* | *4.2m* |

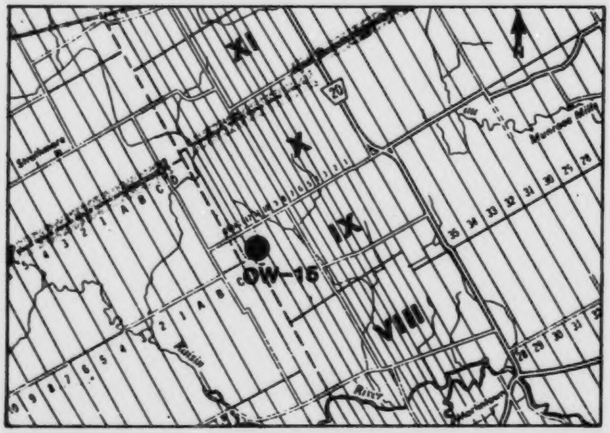


**Figure CW-15-1. LOCATION MAP FOR CHRISTIE QUARRY.**

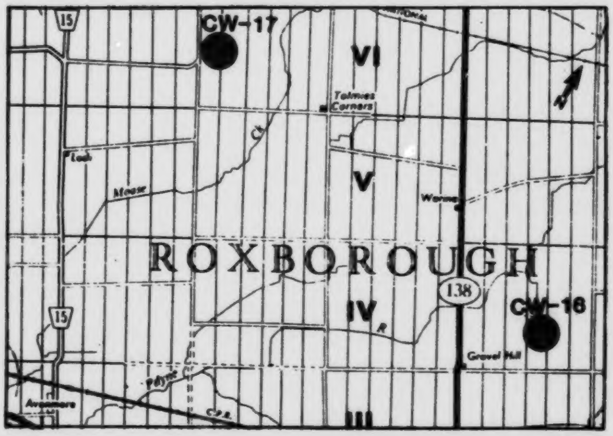


**Figure CW-16-1. LOCATION MAP FOR GRAVEL HILL QUARRY.**

### QUARRY OPERATION

The quarry was opened in 1980 and currently operates on an intermittent basis.

### PROCESSING

The quarried stone is processed by a portable crushing and screening plant.

### PRODUCTS

Granular "A", "B" and "C"

### REFERENCES

Williams, in prep., Appendix 1 – Section LQ CO–4

### MAPS

Williams, Wolf and Carson, 1985a, OGS Map P.2720

## CW–17 A.L. BLAIR CONSTRUCTION CO. LTD. — MOOSE CREEK QUARRY

### LOCATION AND OWNERSHIP

The Moose Creek Quarry is located 3 km southwest of Moose Creek, in Lot 24, Concession 6, Roxborough Township, Stormont County (Figure CW–17–1) and is owned by A. L. Blair Construction Co. Ltd.

### GEOLOGY

The 5.6 m deep quarry exposes fine– to medium–crystalline, thin–bedded, nodular limestone of the lower member, Lindsay Formation. Glacial overburden around the quarry is less than 1 m thick.

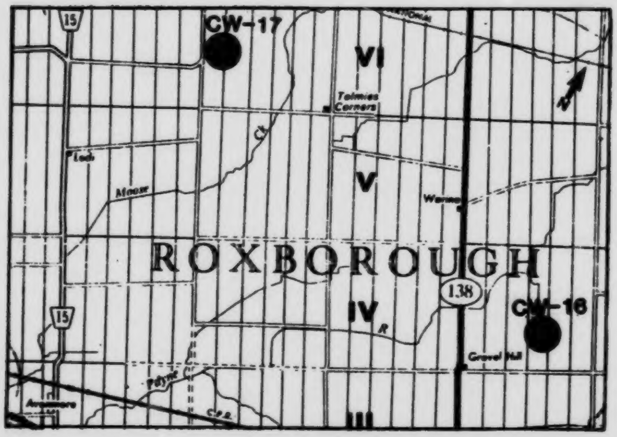


Figure CW–17–1. LOCATION MAP FOR MOOSE CREEK QUARRY.

### Geological Section

| | | Thickness |
|---|---|---|
| *UNIT 1* | *Lindsay Formation, lower member* | *5.6m* |
| | Limestone: light to dark grey–brown, weathers blue– grey to brown; most beds very fine crystalline with some medium crystalline; very thin to rare thick bedded, commonly with shale partings between beds which produce a nodular texture. | |
| *Total thickness* | | *5.6m* |

### QUARRY OPERATION

The stone is quarried by drilling and blasting and produces on an intermittent basis.

### PROCESSING

The stone is processed by a portable crushing and screening plant.

### PRODUCTS

Granular "A", "B" and "C"
3/4 in. Clear Stone

### REFERENCES

Williams, in prep., Appendix 1 – Section LQ CO–5

### MAPS

Williams, Wolf and Carson, 1985a, OGS Map P.2720

## CW–18 A.L. BLAIR CONSTRUCTION CO. LTD. — MARTIN (TAYSIDE) QUARRY

### LOCATION AND OWNERSHIP

This small quarry is located 1.5 km southeast of the Highway 417/Highway 138 interchange, in Lot 10, Concession 10, Roxborough Township, Stormont County (Figure CW–18–1) and is operated intermittently by A. L. Blair Construction Co. Ltd.

The quarry was opened in 1983 and is licensed for an area of 8.1 ha, of which approximately 1 ha has been excavated on a single lift of 6.6 m. Stone from the Martin Quarry was used for the construction of Highway 417 in 1984. Production in 1986 consisted of primarily Granular "A", "B" and "C", 3/4 in. clear stone and screenings.

### GEOLOGY

The 6.6 m deep quarry exposes fine– to medium–crystalline, thin–bedded, nodular limestone of the lower member, Lindsay Formation. Glacial overburden around the quarry is less than 1 m thick.

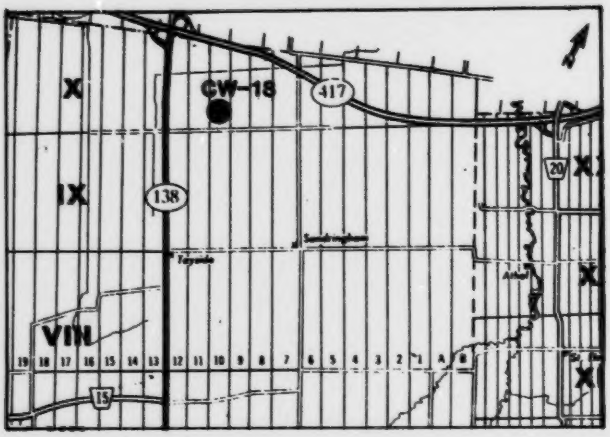


Figure CW-18-1. LOCATION MAP FOR MARTIN (TAYSIDE) QUARRY.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 4 Lindsay Formation, lower member* | *1.8m* |
| Limestone: light to medium grey, weathers light brown; fine to medium crystalline; thin bedded; nodular texture; intraclasts of light grey limestone present; fossiliferous with abundant bryozoa, corals, and brachiopods. | |
| *UNIT 3 Lindsay Formation, lower member* | *1.4m* |
| Limestone: medium grey, weathers light brown; fine crystalline with some beds of coarse crystalline calcarenites; medium bedded, with thin irregular shale partings; intraclasts of light grey limestone in some beds; sparsely fossiliferous. | |
| *UNIT 2 Lindsay Formation, lower member* | *0.9m* |
| Limestone: medium grey, weathers light brown; very fine crystalline, with beds of coarse-crystalline calcarenite; medium bedded, with shale interbeds up to 2 cm thick; intraclasts of limestone in some beds; fossiliferous, with abundant crinoidal debris, brachiopods, and corals. | |
| *UNIT 1 Lindsay Formation, lower member* | *2.5m* |
| Limestone: medium grey, weathers light brown; fine to medium crystalline; thin to medium bedded, with thin irregular shale partings. | |
| *Total thickness* | *6.6m* |

### REFERENCES

Williams, in prep., Appendix 1 – Section LQ AL–1

### MAPS

Williams, Rae and Wolf, 1985a, OGS Map P.2719

## CW–19 BERTRAND & FRERES CONSTRUCTION COMPANY LTD. – ST. ISIDORE QUARRY

### LOCATION AND OWNERSHIP

The St. Isidore Quarry is located 3 km south of St. Isidore de Prescott in Lot 7, Concession 20, South Plantaganet Township, Prescott County, (Figure CW–19–1) and was opened in 1971 to supply asphalt and road base stone for the construction of Highway 417. The St. Isidore Quarry is owned and operated by Bertrand & Freres Construction Company Ltd.

### GEOLOGY

The 10.85 m deep quarry exposes fine– to medium–crystalline, thin– bedded, nodular limestone of the lower member, Lindsay Formation. Glacial overburden around the quarry is less than 1 m thick.

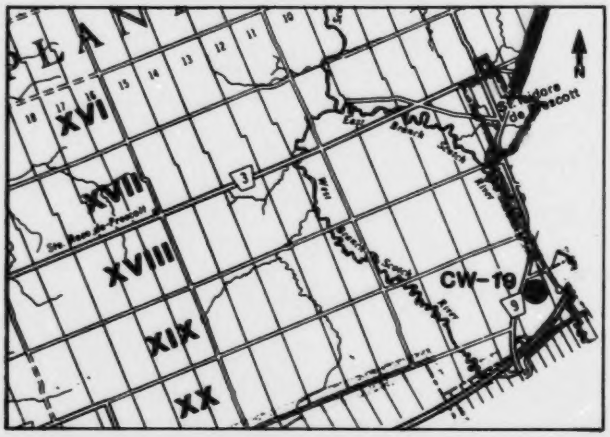


Figure CW-19-1. LOCATION MAP FOR ST. ISIDORE QUARRY.

### Geological Section

*Thickness*

*UNIT 3 Lindsay Formation, lower member* *4.15m*

Limestone: medium grey, weathers light brown; fine to medium crystalline; thin to medium bedded, with thin, irregular shale partings which produce a nodular appearance; top of lower lift at base of unit.

*UNIT 2 Lindsay Formation, lower member* *2.85m*

Limestone, with shale partings: medium grey, weathers light brown; fine crystalline with rare beds coarse crystalline; medium bedded, with shale partings common between beds; nodular in places; fossiliferous with abundant brachiopods, crinoidal debris, and trilobites.

*UNIT 1 Lindsay Formation, lower member* *3.85m*

Limestone, with irregular shale partings: medium to dark grey, weathers light brown; fine to medium crystalline; thin to medium bedded, with thin, irregular shale partings; nodular in places; fossiliferous with abundant brachiopods, corals, trilobites, and burrows.

*Total thickness* *10.85m*

### QUARRY OPERATION

Drilling, blasting and crushing is performed intermittently during a 9–month operating year, though the ready–mix plant on site is operated more continuously. The quarry is mined on two lifts and presently covers an area of approximately 4 ha. Drilling and blasting is performed by a subcontractor on a 2.6 m x 2.6 m pattern with 7.6 cm diameter holes. A portable crushing system is used at the site.

### PROCESSING

The quarried stone is processed by a portable crushing and screening plant.

### PRODUCTS

Granular "A", "B" and "D"
Concrete Stone
HL4, HL6

### REFERENCES

Williams, in prep., Appendix 1 – Section LQ AL–2

### MAPS

Williams, Rae and Wolf, 1985a, OGS Map P.2719

## CW–20 R. TIERNEY — TIERNEY QUARRY

### LOCATION AND OWNERSHIP

This small quarry, recently opened by R. Tierney in Lot 28, Concession 3, Alfred Township, Prescott County, (Figure CW–20–1), is located about 3 km northwest of the Village of Alfred.

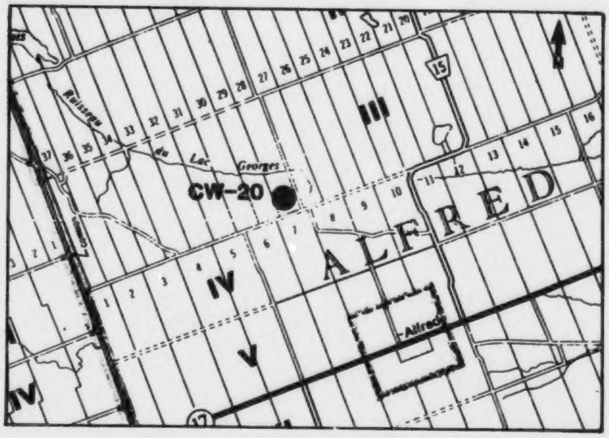


**Figure CW-20-1. LOCATION MAP FOR TIERNEY QUARRY.**

### GEOLOGY

The 3.0 m deep quarry exposes interbedded limestone, shale and sandstone of the St. Martin Member of the Rockcliffe Formation. The thin–bedded limestones are fine crystalline, and often contain abundant fossil debris. During field work in July, 1986, several large (10 to 22 cm) fossil nautiloids were observed. The grey–green shales and sandstones are often burrowed with well developed trace fossils occurring on bedding surfaces. The upper 0.5 m is deeply weathered producing a thin–bedded interval of shale and sandstone. Glacial overburden around the quarry may be up to 2 m thick in places.

### PRODUCTS

The Tierney Quarry presently produces sized stone, riprap, fill and agricultural lime. A 3/4 yd. diesel shovel is used to strip overburden and to excavate stone.

### REFERENCES

None

### MAPS

None

## CW–21 BERTRAND & FRERES CONSTRUCTION COMPANY LTD. — L'ORIGNAL QUARRY

### LOCATION AND OWNERSHIP

This large quarry is located 5 km west of the Village of L'Orignal in Lots 213–215, Longueuil Township, Prescott County (Figure CW–21–1). The quarry is owned and operated by Bertrand & Freres Construction Company Ltd.

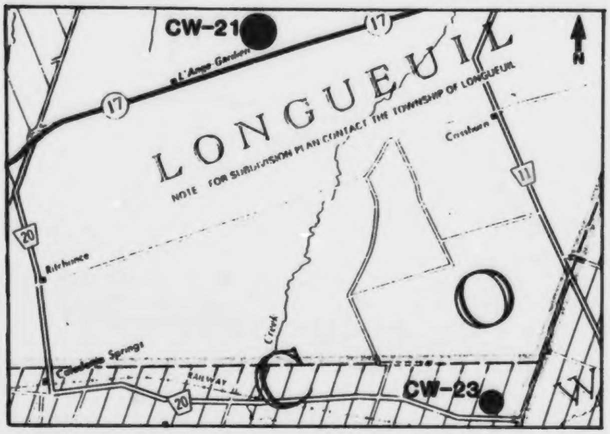


**Figure CW-21-1. LOCATION MAP FOR L'ORIGNAL QUARRY.**

## GEOLOGY

The 15.2 m deep quarry exposes fine– to coarse–crystalline, thin– to medium–bedded limestones of the upper member, Bobcaygeon Formation. In addition, a second quarry, which is now filled with water, had been opened (Hewitt and Vos, 1972, p.15) 3 km north of the operating quarry. Glacial overburden around the active quarry is less than 0.5 m thick.

### Geological Section

| | | Thickness |
|---|---|---|
| *UNIT 4* | *Bobcaygeon Formation, upper member* | *1.6m* |
| | Limestone: medium grey, weathers grey–brown; fine to medium crystalline; thin bedded, with shale partings; fossiliferous, with abundant brachiopods, bryozoa, trilobites, and crinoidal debris. | |
| *UNIT 3* | *Bobcaygeon Formation, upper member* | *3.0m* |
| | Limestone: light to medium grey, weathers dark grey; fine crystalline with some coarse–crystalline intervals; medium bedded, with shale interbeds up to 1 cm thick; fossiliferous with abundant bryozoa, brachiopods, and crinoidal debris. | |
| *UNIT 2* | *Bobcaygeon Formation, upper member* | *0.4m* |
| | Limestone: light grey, weathers dark grey; medium crystalline; one single bed; shale interbeds 5 cm thick occur at base and top of unit. | |
| *UNIT 1* | *Bobcaygeon Formation, upper member* | *10.2m* |
| | Limestone: dark grey, weathers same; fine to coarse crystalline; thin to medium bedded, with thin shale interbeds; fossiliferous, with abundant crinoidal debris, graptolites, bryozoa, brachiopods and burrows. | |
| *Total thickness* | | *15.2m* |

## CHEMICAL ANALYSES*

| | Components in Percent | |
|---|---|---|
| | Main quarry<br>Units 2-4<br>3/4 in. crushed stone | North quarry<br>2 in. crusher run |
| $SiO_2$ | 4.33 | 22.1 |
| $Al_2O_3$ | 0.47 | 4.50 |
| $Fe_2O_3$ | 0.20 | 1.64 |
| MgO | 1.10 | 3.11 |
| CaO | 51.4 | 35.3 |
| $P_2O_5$ | 0.11 | 0.12 |
| $SO_3$ | 0.21 | 1.81 |
| L.O.I. | 42.0 | 30.6 |
| Total | 99.8 | 99.2 |

* *after Hewitt and Vos, 1972, p.15.*

## QUARRY OPERATION

The quarry covers approximately 12 ha and is currently excavated in two lifts of 6.1 m each. A third lift is scheduled to be developed as the haulage distance from the blast face becomes too great. Blasted stone is presently hauled a distance of approximately 500 m by four 30–ton Euclid trucks.

A 3–yd. Northwestern diesel shovel and Cat 980–B loader are used for the loading of haulage trucks. Stone from the first (upper) lift is used primarily for granular products and the second lift, which has a silica content of approximately 4%, is used for concrete and asphalt products.

Drilling and blasting is subcontracted, and a 2.7 m x 2.7 m pattern is used with 7.6 cm diameter holes. A 4 in. Flygt submersible pump is used to dewater the quarry during the operating season.

## PROCESSING

The blasted stone is hauled to a primary hopper that feeds a Seco vibratory grizzly, from which +6 in. oversize is sent to a Cedarapids 30 in. x 30 in. impactor crusher. Minus 6 in. material is fed to a 5 ft. x 16 ft. double–deck screen that produces 2 in. clear and Granular "A" that are sent to two 40–ton bins, and a +2 in. oversize that is sent to a Pulvamatic 45 in. cage crusher in closed circuit with a 5 ft. x 16 ft. screen. Stone leaving the Cedarapids impactor is passed over a 4 ft. x 16 ft. single–deck screen, from which –3/4 in. material is fed to a 4 ft. x 10 ft. triple–deck screen. Plus 3/4 in. oversize is sent to a 30 in. Ferano Roller crusher in closed circuit with the 4 ft. x 10 ft. screen, which produces 3/4 in. clear, 1/2 in. clear, and 1/4 in. dust to 25–ton storage bins. Two 25–ton Volvo trucks and two 30–ton Euclid trucks load stone products from the bins for stockpiling.

## PRODUCTS

Armour Stone
Riprap
Granular "A", "B" and "D"

Photo CW-21-1. WORKING FACE AT L'ORIGNAL QUARRY (LOOKING NORTHWEST).

1/4 in. Dust
3/4 in. Clear
1/2 in. Clear
HL4, HL6

### REFERENCES

Goudge, 1938, p.154
Hewitt, 1960, p.80
Hewitt and Vos, 1972, p.15
Williams, in prep., Appendix 1 – Sections LQ HA–1 and AQ HA–1

### MAPS

Williams, Rae and Wolf, 1985b, OGS Map P.2718

## CW–22 SINTRA INC. — ROSS QUARRY

### LOCATION AND OWNERSHIP

The Ross Quarry, located 8 km southeast of Hawkesbury in Lot 29, Concession 2, East Hawkesbury Township, Prescott County (Figure CW–22–1), is owned by Sintra Inc. and operates on an intermittent basis for local road construction projects.

### GEOLOGY

The quarry exposes a total of 9.5 m of sandstone and limestone of the lower and upper (St. Martin) members of the Rockcliffe Formation (Figure CW–22–2). The lower member consists of quartz–rich sandstones interbedded with green shale beds. The upper (St. Martin) member consists of coarse–grained calcarenites. The beds in the quarry dip to the east at about 10° exposing a stratigraphic section which is greater than the depth of the quarry (which is about 6.5 m deep). When visited in 1986 the quarry was partially filled with water. Glacial overburden around the quarry is 1 to 2 m thick.

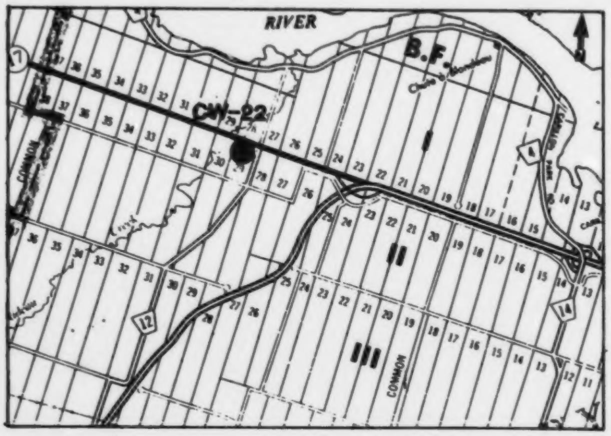


Figure CW–22–1. LOCATION MAP FOR ROSS QUARRY.

### Geological Section

*Thickness*

*UNIT 2 Rockcliffe Formation, St. Martin Member* *4.5m*

Limestone: medium grey, weathers grey–brown; coarse crystalline, commonly a coarse–grained calcarenite, with abundant fragmented crinoidal debris; massive bedded, 1–2 m thick with well developed cross–beds in some intervals; bedding plane contacts are stylolitic; fossiliferous, with abundant brachiopods; lower contact of unit sharp.

*UNIT 1 Rockcliffe Formation, lower member* *5.0*

Sandstone with shale interbeds: light grey–green, weathers grey–green, with shales usually a slightly darker colour; fine–grained, well–sorted sandstone; burrows common, especially at shale– sandstone contacts.

*Total thickness* *9.5m*

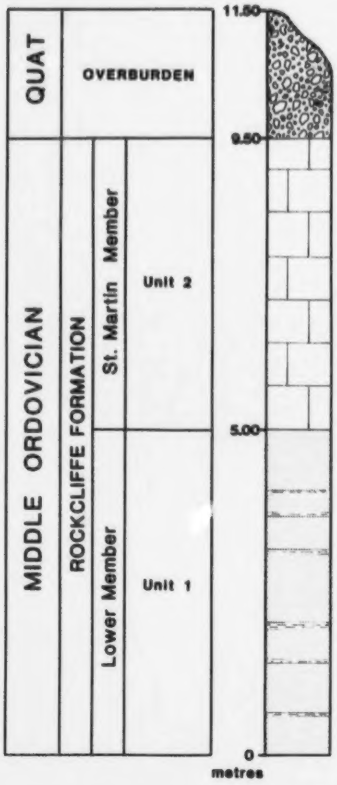

QUAT
OVERBURDEN
MIDDLE ORDOVICIAN
ROCKCLIFFE FORMATION
St. Martin Member
Unit 2
Lower Member
Unit 1
11.50
9.50
5.00
0
metres

Figure CW-22-2. STRATIGRAPHIC COLUMN FOR ROSS QUARRY.

## REFERENCES

Parks, 1912
Goudge, 1938, p. 155–156
Williams, in prep., Appendix 1 – Section LQ HA–2

## MAPS

Williams, Rae and Wolf 1985b, OGS Map P.2718

# CW-23 CLIFTONDALE AGGREGATES – CLIFTONDALE (McALPINE) QUARRY

## LOCATION AND OWNERSHIP

The Cliftondale Quarry is located 7 km west of the Town of Vankleek Hill, Lot 2, Concession 1, Caledonia Township, Prescott County (Figure CW–23–1) and is a family operation owned by Dale and Lorrie Clare. The property has been intermittently quarried for seventy years and was previously known as the McAlpine Quarry. The old quarry is located immediately to the east of the current workings.

## GEOLOGY

The current quarry extends southeastward into a northwest–southeast trending hillside just west of the old workings. The recent blasting has revealed that a fault zone parallels the hillside. The main fault exposed shows a downthrow to the southwest of more than 10 m, with several parallel minor faults showing displacements of less than 1 m each. The faults all trend at 130° and dip 70° to the southwest and are normal faults, commonly paralleled by thin calcite veins. The presence of a 1 m wide breccia zone at the extreme north end of the quarry suggests that other faults may be present north of the current exposure.

The thickest part of the quarry, southwest of the main fault, exposes 10.2 m of thick–bedded limestone of the upper member of the Bobcaygeon Formation. To the northeast, 4.8 m of thin–bedded, shaly limestone of the middle member, Bobcaygeon Formation are exposed. The beds within each fault block are essentially horizontal, with minor drag folds present along the main fault. The breccia zone is characterized by angular limestone clasts set in a matrix of very large calcite crystals.

Glacial overburden at the crest of the hill is up to 3 m thick.

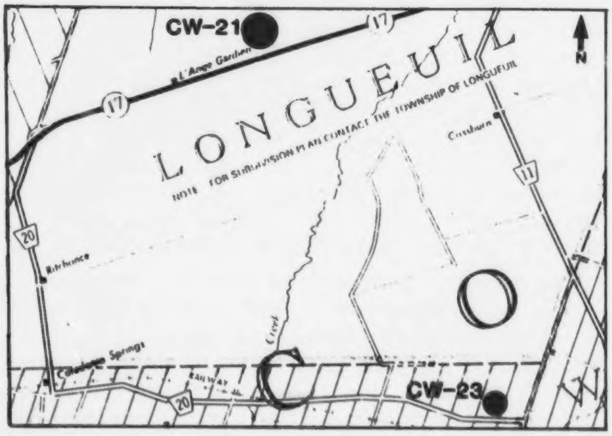

CW-21
17
L'Ange Gardien
17
N
LONGUEUIL
NOTE FOR SUBDIVISION PLAN CONTACT THE TOWNSHIP OF LONGUEUIL
11
20
Caledonia Springs
Railway
Creek
C
O
W
20
CW-23

Figure CW-23-1. LOCATION MAP FOR CLIFTONDALE (McALPINE) QUARRY.

**Geological Section**

| *Southwest of Main Fault* | *Thickness* |
|---|---|
| *UNIT 1 Bobcaygeon Formation, upper member* | *10.2m* |

Limestone: medium grey, weathers light grey to grey- brown at top; medium crystalline, with both fine- and coarse-crystalline beds present; medium to thick bedded (20-80 cm), with rare, very thin, shale partings; small calcite crystals common in coarse- crystalline beds, thin calcite veins present adjacent to fault zone; very fossiliferous, with abundant crinoidal debris and brachiopods; at east end of quarry main fault zone delineates edge of outcrop, while outcrop continues across fault on west side of quarry.

| *Total thickness* | *10.2m* |
|---|---|

*Northeast of Main Fault*

| *UNIT 3 Bobcaygeon Formation, middle member* | *1.7m* |
|---|---|

Limestone, with shale interbeds: medium grey, weathers grey-brown; fine to medium crystalline; thin bedded (10 cm) with shale partings 2-3 cm thick between beds, sharp and planar contacts; sparsely fossiliferous; lower contact of unit sharp and planar.

| *UNIT 2 Bobcaygeon Formation, middle member* | *1.2m* |
|---|---|

Limestone: medium grey, weathers dark grey-brown; medium to coarse crystalline; thick bedded (30-70 cm), with sharp, planar contacts, shale partings less than 1 cm thick; fossil fragments common; lower contact of unit sharp and planar.

| *UNIT 1 Bobcaygeon Formation, middle member* | *1.9m* |
|---|---|

Limestone, with shale interbeds: medium grey, weathers same; fine to medium crystalline; thin bedded (5 cm, rarely 10 cm) with shale partings up to 2 cm thick, sharp and planar contacts; abundant fossil fragments.

| *Total thickness* | *4.8m* |
|---|---|

### QUARRY OPERATIONS

The quarry is excavated on a single lift of 12.1 m, approximately to the water table level. Potential for excavation of an additional 10.7 m exists. Drilling, blasting and crushing is contracted; screening and trucking is performed by Cliftondale Aggregates.

An 80-ton scale with computerized printout is available on-site. The only other scale available in the area is that owned by Bertrand & Freres Construction Co. at the L'Orignal Quarry.

### PRODUCTS

Quarry Rock
Blasted Rock
Pit Run
Granular "A" and "B"
2 in. Clear
1 in. Clear
5/8 in. Clear
3/8 in. Clear
Filter Sand (government approved)
Stone Dust and Liming Dust

**References**

Goudge, 1938, p. 155

**Maps**

None

## CW-24 SINTRA INC. — LEROUX (SKYE) QUARRY

### LOCATION AND OWNERSHIP

The Leroux Quarry, owned and intermittently operated by Sintra Inc. is located 6 km south of the village of St. Bernardin, in Lot 12, Concession 8, Caledonia Township, Prescott County (Figure CW-24-1).

### GEOLOGY

The 9.3 m deep quarry exposes fine-crystalline, thick-bedded limestones of the lower member, Bobcaygeon Formation. Glacial overburden around the quarry is about 1 m thick.

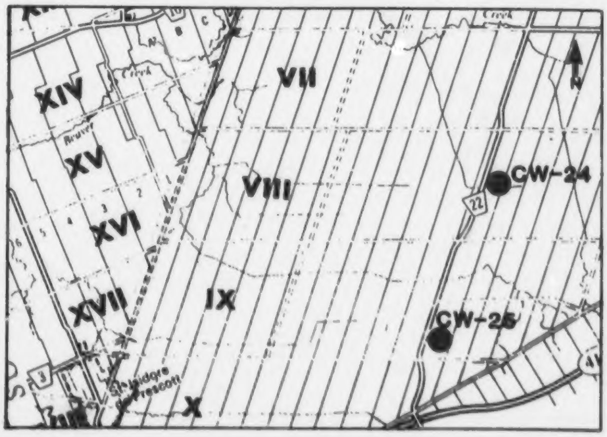
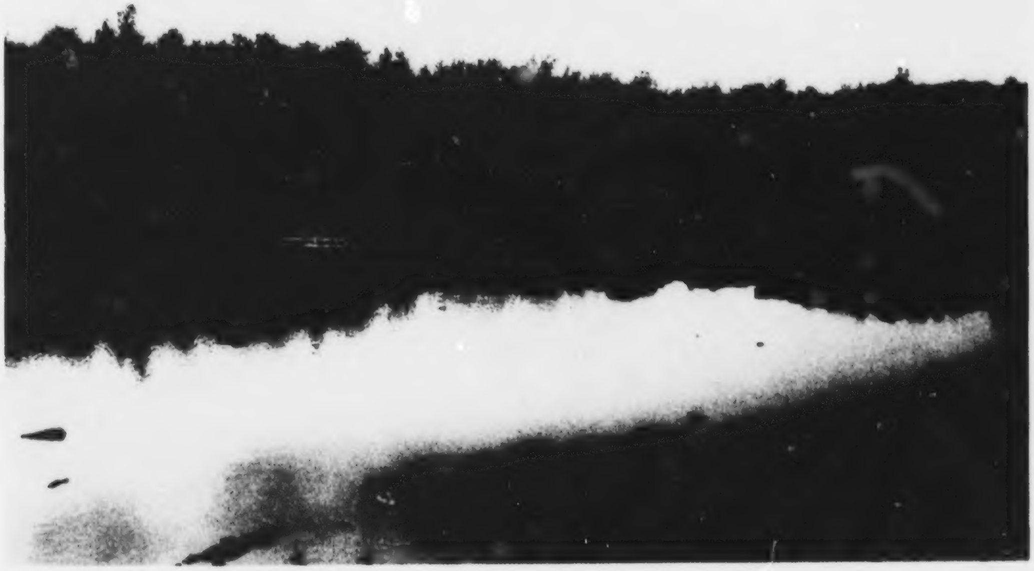


Figure CW-24-1. LOCATION MAP FOR LEROUX (SKYE) QUARRY.

Photo CW-24-1. QUARRY SECTION AT LEROUX (SKYE) QUARRY (LOOKING SOUTH).



## Geological Section

| | | *Thickness* |
|---|---|---|
| *UNIT 4* | *Bobcaygeon Formation, lower member* | *3.0m* |

Limestone: light to medium grey, weathers light buff and brown; fine crystalline; thin to medium bedded, with undulating shale partings; small calcite-filled vugs present; fossiliferous with abundant brachiopods, gastropods, crinoidal debris and corals; lower contact of unit sharp and planar.

| | | |
|---|---|---|
| *UNIT 3* | *Bobcaygeon Formation, lower member* | *2.5m* |

Limestone: grey, weathers tan; fine crystalline; massive bedded with black shale partings; sparsely fossiliferous with fragments of trilobites and brachiopods.

| | | |
|---|---|---|
| *UNIT 2* | *Bobcaygeon Formation, lower member* | *0.8m* |

Limestone: grey, weathers tan; fine crystalline; medium bedded with interbeds of 1 cm thick black shale beds, undulating contacts; rusty brown stained beds; scattered fossil fragments.

| | | |
|---|---|---|
| *UNIT 1* | *Bobcaygeon Formation, lower member* | *3.0m* |

Limestone: light to medium grey, weathers light buff and tan; very fine to fine crystalline; medium to massive bedded, with black shale partings and undulating contacts; calcite-filled vugs present; small stylolites occur within limestone beds; some fossil fragments present.

| | |
|---|---|
| *Total thickness* | *9.3m* |

## QUARRY OPERATIONS

The Leroux Quarry is currently operating from a single lift of 4.5 m that has exposed an area of about 1 ha.

## PROCESSING

The quarried stone is processed by a portable crushing and screening plant comprising a Hewitt–Robins 36 in. x 42 in. primary jaw crusher which feeds a Hewitt–Robins 5 ft. x 16 ft. triple-deck screening plant. A 4 1/4 ft. Symons cone is operated as a secondary crusher in closed circuit with the screening plant.

## PRODUCTS

Granular "A" and "B"

## REFERENCES

None

## MAPS

Williams, Wolf and Carson, 1985a, OGS Map P.2720

Photo CW-24-2. PORTABLE PROCESSING PLANT AT LEROUX (SKYE) QUARRY (LOOKING EAST).

## CW-25 CRUICKSHANK CONSTRUCTION LTD. — GAUTHIER QUARRY

### LOCATION AND OWNERSHIP

The Gauthier Quarry is located 8 km east of St. Isidore de Prescott in Lot 12, Concession 9, Caledonia Township, Prescott County (Figure CW-25-1). The quarry is operated by Cruickshank Construction Ltd., on a local demand basis, and has been opened on a single lift of 5.5 m over an area of about 2 ha. The primary products are Granular "A" and "B".

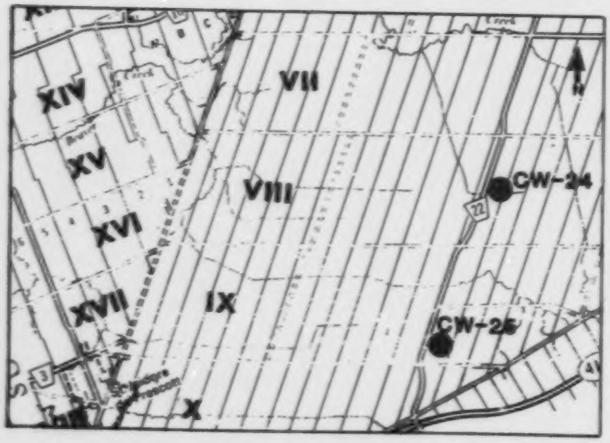


Figure CW-25-1. LOCATION MAP FOR GAUTHIER QUARRY.

### GEOLOGY

The 5.5 m deep quarry exposes interbedded, medium-crystalline and coarse-grained, medium- to thick-bedded limestones of the lower member of the Bobcaygeon Formation. Glacial overburden around the quarry is 1 to 2 m thick.

#### Geological Section

| | | *Thickness* |
|---|---|---|
| *UNIT 1* | *Bobcaygeon Formation, lower member* | *5.5m* |

Limestone: medium grey, weathers light grey-brown to medium grey; medium to coarse crystalline, with very coarse-grained calcarenite beds; medium to thick bedded (10-50 cm), contacts are sharp, irregular, with some very thin, black shale partings (less than 0.25 cm); calcite crystals are present in coarse-crystalline beds; calcarenites more abundant in upper part of quarry; fossiliferous, with abundant brachiopods, crinoidal debris, and trilobites.

*Total thickness* *5.5m*

### REFERENCES

None

### MAPS

None

## CW-26 A.L. BLAIR CONSTRUCTION CO. LTD. — DUVAL QUARRY

### LOCATION AND OWNERSHIP

This recently opened quarry, located 6 km east of the village of Dunvegan in Lot 11, Concession 7, Kenyon Township, Glengarry County (Figure CW-26-1), is operated by the A. L. Blair Construction Co. Ltd.

**Photo CW-26-1. OPENING OF FIRST LIFT AND PORTABLE PROCESSING PLANT AT DUVAL QUARRY (LOOKING SOUTH).**

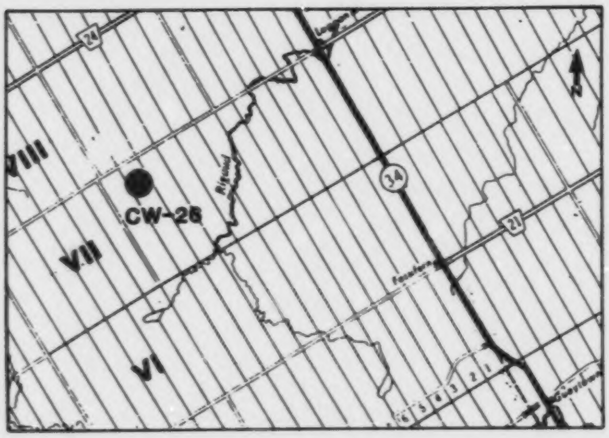


**Figure CW-26-1. LOCATION MAP FOR DUVAL QUARRY.**

## GEOLOGY

The 7.0 m deep quarry exposes medium- to coarse-crystalline, medium-bedded limestones of the lower member, Bobcaygeon Formation. Glacial overburden around the quarry is less than 1 m thick.

### Geological Section

| | *Thickness* |
|---|---|
| *UNIT 1 Bobcaygeon Formation, lower member* | *7.0m* |
| Limestone: medium grey, weathers same; medium to coarse crystalline, with beds of very coarse-grained calcarenites; medium bedded, sharp and planar contacts, some with thin, dark grey, shale partings; small calcite crystals present in coarse- crystalline beds; fossiliferous with abundant brachiopods, trilobites, and crinoidal debris. | |
| *Total thickness* | *7.0m* |

## QUARRY OPERATION

The quarry is currently producing from a single lift of approximately 7.0 m which has been opened over an area of about 1.6 ha.

## PROCESSING

A portable crushing and screening plant is used to process the quarry run material.

## PRODUCTS

Granular "A" and "B"
3/4 in. Clear Stone

## REFERENCES

None

## MAPS

None

## CW-27 CRUICKSHANK CONSTRUCTION LTD. — GREEN VALLEY QUARRY

### LOCATION AND OWNERSHIP

This large quarry is located in Lots 29 and 30, Concession 6, Lancaster Township, Glengarry County (Figure CW-27-1). The quarry is owned and operated by Cruickshank Construction Ltd., and was purchased in 1981 from Menard Construction Limited. Cruickshank Construction Ltd. is engaged in road construction projects and also provides custom drilling and blasting services. The quarry is licensed for approximately 31 ha.

### GEOLOGY

The three lifts in the quarry expose 13.75 m of limestones from the Gull River and Bobcaygeon Formations (Figure CW-27-2). The lower member of the Gull River Formation consists of interbedded fine-crystalline dolostone and microcrystalline limestone. The upper member consists of thin-bedded shaly limestone, which is overlain by the thick-bedded limestones of the lower member of the Bobcaygeon Formation.

On the south face of the quarry, a nearly vertical fault is present which trends 115° with a 40 cm downthrow to the southwest. The fault zone is up to 60 cm wide with thick (5-7 cm) calcite veins in the shear zone. A second fault zone, several metres wide with only minor displacement, is present in the northeast corner of the quarry. Glacial overburden around the quarry is up to 2 m thick.

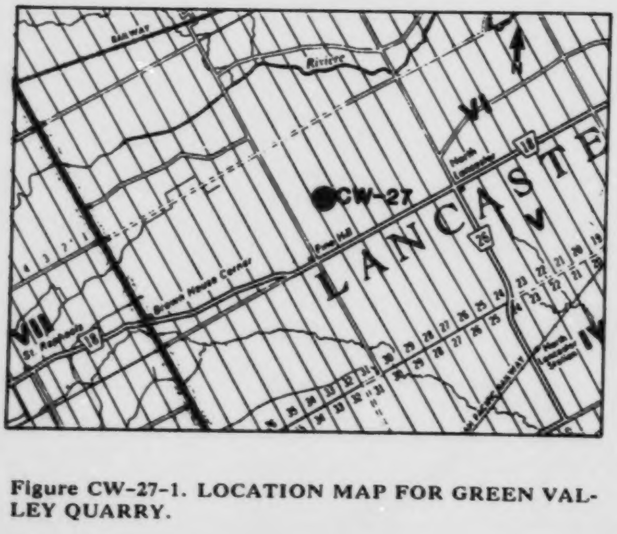


Figure CW-27-1. LOCATION MAP FOR GREEN VALLEY QUARRY.

### Geological Section

*Thickness*

*UNIT 4 Bobcaygeon Formation, lower member* *3.5m*

Limestone: grey-brown to dark grey, weathers light grey-brown to red-brown; very fine to fine crystalline; massive bedded, rarely thin bedded, with very thin, dark shale partings between some beds; fossiliferous with abundant crinoidal debris, brachiopods, bryozoa, cephalopods, corals, and burrows; lower contact of unit sharp and planar.

*UNIT 3 Gull River Formation, upper member* *4.2m*

Limestone: light to medium brown and grey-brown, weathers blue-grey to light brown and red- brown; microcrystalline to fine crystalline; very thin bedded, with thin to medium beds at base of unit, shale interbeds up to 2 cm thick common between beds; fossiliferous with abundant crinoidal debris, brachiopods, bryozoa, cephalopods, and burrows; lower contact of unit sharp and planar at 2 cm thick shale parting; top of 2nd lift at top of unit.

*UNIT 2 Gull River Formation, upper member* *3.9m*

Limestone: dark grey, weathers medium grey; microcrystalline to very fine crystalline (rare fine- and coarse-crystalline beds); thin to medium bedded (5-15 cm), sharp contacts, some are stylolitic, and some have very thin dark grey shale partings; some beds contain intraclasts of light grey microcrystalline limestone; abundant calcite crystals present, either disseminated or replacing fossil fragments; fossiliferous with abundant brachiopods; lower contact of unit sharp at base of 4 cm thick shaly limestone bed; top of lower lift at top of unit.

*UNIT 1 Gull River Formation, lower member* *2.2m*

Limestone capped with dolomitic limestone: medium grey to light grey; weathers light grey to light green-grey; very fine to fine crystalline; limestones thin bedded (10 cm), dolomitic limestone a single bed (80 cm thick) which caps unit; sharp and planar contacts; burrows common on bedding planes.

*Total thickness* *13.8m*

### QUARRY OPERATION

The quarry has an excavated area of about 4 ha, and is operated on three lifts of 3.5 m, 4.2 m and 6.1 m with a maximum depth of 18.3 m projected. The overburden is a mixture of soil and caprock; the latter is removed by blasting or bulldozer-ripper. Drilling is performed with Gardner-Denver air track on a drill pattern of 2.4 m x 2.4 m with 7.6 cm diameter holes.

### PROCESSING

A portable crushing system is set up on-site, consisting of a Cedarapids 3645-H primary impeller crusher, a Cedarapids 855 Commander secondary crusher and a Suntract 5 ft. x 14 ft. double-deck screening plant. Stone leaving the primary crusher (-3 in.) can be stockpiled as Granular "B" or sent to a 4 ft. x 6 ft. Powerscreen that produces -5/8 in. material for a stockpile and -3 in. + 5/8 in. material that is sent to the secondary crusher. After secondary crushing the stone is transferred to the Suntract screening plant, which produces stone dust, 3/4 in. clear and 3/4 in. concrete stone.

Photo CW-27-1. PORTABLE PROCESSING PLANT AT GREEN VALLEY QUARRY (LOOKING NORTHWEST).

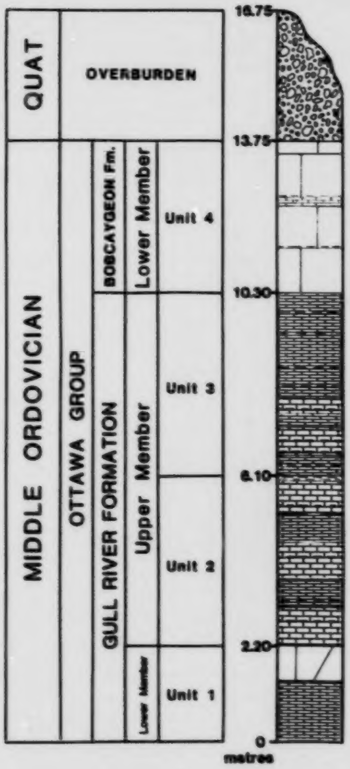


Figure CW-27-2. STRATIGRAPHIC COLUMN FOR GREEN VALLEY QUARRY.

The stone quality is sufficient for the production of HL grades, though the plant would need modifications to the screening process.

### PRODUCTS

Granular "A" and "B"
3/4 in. Clear (Septic Bed Stone)
3/4 in. Concrete Stone
Stone Dust

### REFERENCES

Williams, in prep., Appendix 1 – Section LQ CO-6

### MAPS

Williams, Wolf and Carson, 1985a, OGS Map P.2720

## CW-28 KARNUK MARBLE INDUSTRIES INC. – CORNWALL PLANT

### LOCATION AND OWNERSHIP

Karnuk Marble is a stone dressing plant which was established on Marleau Avenue on the east side of Cornwall in 1984. It is owned and operated by Karnuk Marble Industries Inc. and in 1986 employed 14 to 20 people in cutting and polishing marble and granite blocks obtained from a variety of sources. A planned addition of a further 4,000 m² of working space will double the plant's present capacity. The modern automated equipment was almost entirely supplied by the Breton Company of Castello di Godego, Italy.

### PLANT OPERATION

In 1986 the market for polished granite slabs and tiles was particularly strong. Blocks of Vermilion Bay Pink from northwestern Ontario were being used along with a variety of granites from Quebec.

In addition to the marbles imported from Europe, blocks of coarse-grained white calcitic marble, faintly veined in green or peach, were being obtained from the Tatlock area north of Perth, Ontario. Also, blocks of dark beige limestone from the Wiarton area were in occasional use, although the best thickness of 50 cm to 60 cm was less than desirable for optimum sawing capacity.

A massive black limestone from the nearby MacLeod Quarry of Cornwall Gravel Company Limited, is extensively used in the making of polished tiles (see Quarry CW-14). The stone is a black micrite containing fossil fragments and calcite pore fillings. It belongs to the lower member, Bobcaygeon Formation and occurs in two horizontal beds 90 cm to 125 cm thick at the top of the quarry section.

### PROCESSING

Quarry blocks from various sources are received by truck and are handled in the yard by a 25-ton gantry crane.

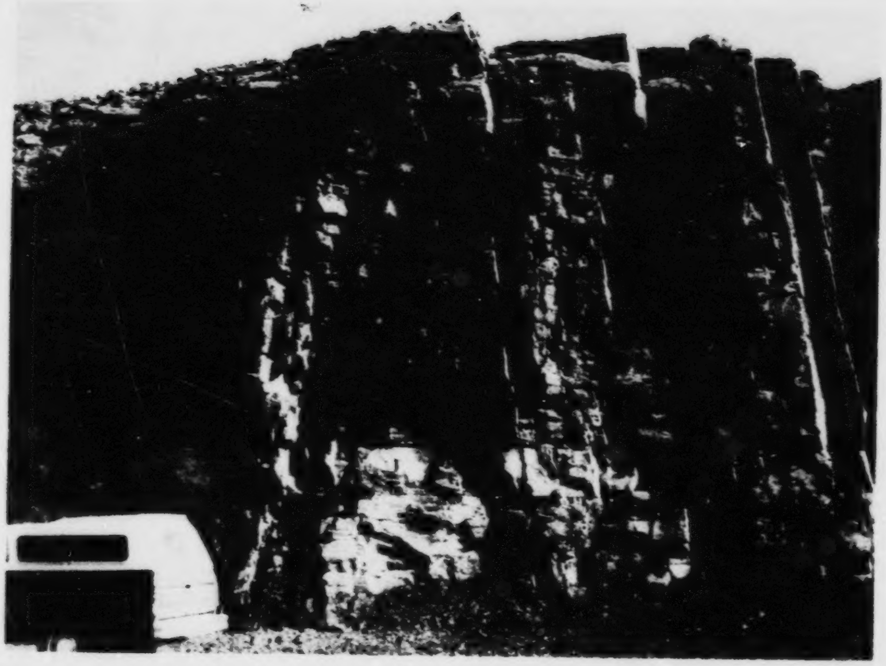


Photo CW-27-2. EAST FACE AT GREEN VALLEY QUARRY SHOWING VERTICAL JOINTING.

Granite blocks are positioned two to a car for sawing. Preferred sizes are 3 m by 1.5 m by widths of about 1 m. Blocks are bonded and levelled on the car with cement, sand and straw. Marble blocks are similiarly handled, except that only one block is sawn at a time. Preferred size is 2.2 m by 1.2 m by 1.2 m. Loaded cars are moved on rail to the saws.

Blocks are slabbed by gang saws using a slurry of steel shot, lime and water as the cutting medium. Cutting rate in granite is typically 4.5 cm per hour, requiring about 70 hours to reduce the two blocks to slabs of about 3 cm in thickness. Cutting rates in marble are typically 16 to 20 cm per hour, requiring about 10 hours to completely slab the block. Gang saw blades used for cutting granite must be replaced every 4 or 5 cuts due to excessive wear. Blades are imported from Italy.

The finishing plant consists essentially of two lines: one for tiles and one for slabs. Polished tiles of granite and black limestone were in particular demand in 1986.

Unslabbed blocks are fed directly to the tile cutting machine which consists of three vertical and one horizontal diamond-studded circular saw blades cutting simultaneously. Three strips are cut at a time in thicknesses of 1.25 inches, .75 inches or .375 inches, in

Photo CW-28-1. BLOCKS OF BLACK BOBCAYGEON FORMATION LIMESTONE AT CORNWALL PLANT.

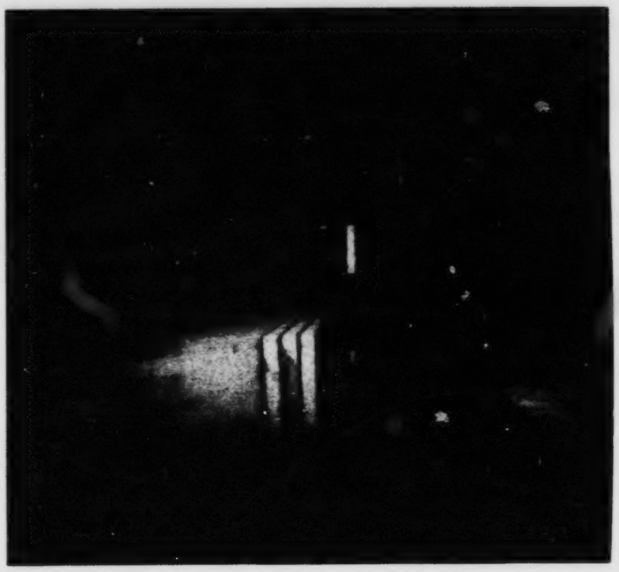


Photo CW-28-2. CUTTING TILES FROM A BLOCK OF BOBCAYGEON FORMATION LIMESTONE AT CORNWALL PLANT.

widths of 12 inches and lengths of 7 or 8 ft. These strips proceed in single file beneath two diamond calibrating heads which grind the strips to within 1 mm of their final thickness. Final finish is provided by a 12–head polishing machine. The first six heads prepare the surface using abrasives and the last six provide the final polish. Tiles are cut and trimmed to their final 12–inch square size and packaged for shipment. The tile line requires five labourers and one supervisor.

Slabs of either granite or marble are removed from the gangsaws and fed to a slab polisher via two side–by–side drive belts, each 1 m wide. Hence, slabs up to 2 m in width and any length can be polished. The 15 polishing heads are equipped with composite pads consisting of sand and wood for polishing marble; lead and felt pads for granite. Tin oxide, oxalic acid and colour dyes are minor additives to the pad polishing medium.

Two edges of each slab are squared by diamond saws; a third edge by wire saw. Final cutting to desired size is accomplished in a diamond bridge saw.

# Carleton Place District

## INTRODUCTION

Carleton Place District is situated in the Eastern Region of southern Ontario nestled between the Ottawa River to the north, Cornwall District to the east, Brockville District to the south, and Tweed and Pembroke districts to the west and northwest, respectively. The district includes the Regional Municipality of Ottawa–Carleton and Lanark County (Figure CP–0–1).

Sixty–eight quarry properties are documented in the Carleton Place District quarry inventory (Appendix IV, Volume I) including 15 active quarries, 9 intermittently active quarries and 44 past producing quarries of geological significance. In addition, the Steep Rock Calcite Tatlock Quarry (CP–25) is documented.

All of the currently active and intermittently active quarries were visited during the project and include the following:

| | |
|---|---|
| *CP–1* | *Thomas Cavanagh Construction Ltd. – Arnprior Quarry (intermittent)* |
| *CP–2* | *Thomas Cavanagh Construction Ltd. – Kinburn Quarry (intermittent)* |
| *CP–3* | *R. C. Lyle (Burntlands Aggregates Ltd.) – Almonte Quarry (intermittent)* |
| *CP–4* | *Thomas Cavanagh Construction Ltd. – West Carleton Quarry (active)* |

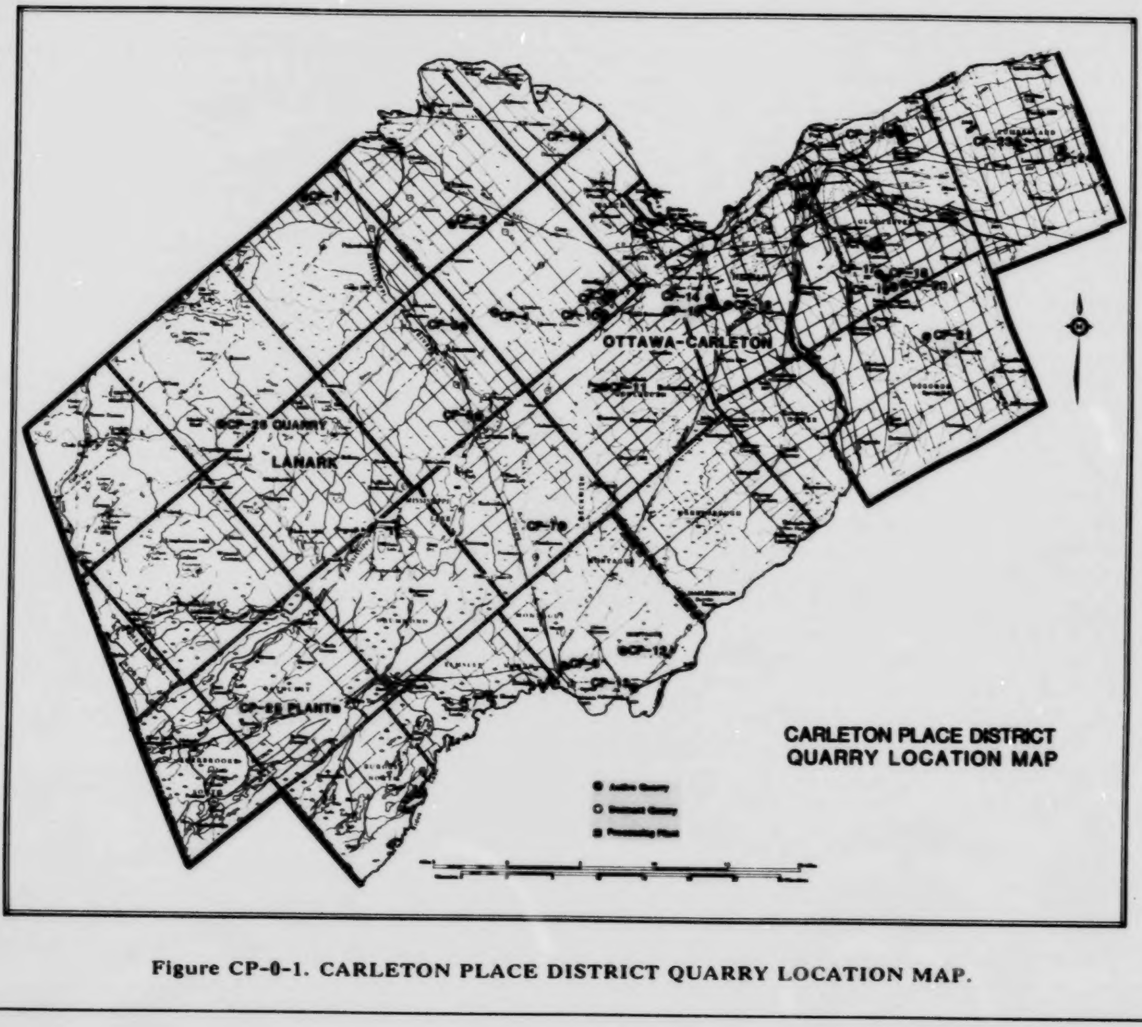


Figure CP-0-1. CARLETON PLACE DISTRICT QUARRY LOCATION MAP.

| | |
|---|---|
| *CP–5* | *Duffy Road Oiling Ltd. – Carleton Place Quarry (intermittent)* |
| *CP–6* | *George Kennedy – Dunrobin Quarry (intermittent)* |
| *CP–7* | *Thomas Cavanagh Construction Ltd. – Franktown Quarry (intermittent)* |
| *CP–8* | *Warren Paving & Materials Group Ltd. – Smiths Falls (Dibblee) Quarry (intermittent)* |
| *CP–9* | *Spratt Sand and Gravel Ltd. – Spratt Quarry (active)* |
| *CP–10* | *West Carleton Sand and Gravel Inc. – Clarke Quarry (active)* |
| *CP–11* | *Thomas Cavanagh Construction Ltd. – Goulbourn Quarry (active)* |
| *CP–12* | *G. Tackaberry and Sons Construction Co. Ltd. – Rosedale Quarry (intermittent)* |
| *CP–13* | *G. Tackaberry and Sons Construction Co. Ltd. – Kilmarnock Quarry (intermittent)* |
| *CP–14* | *R. W. Tomlinson Ltd. – Fallowfield Quarry (active)* |
| *CP–15* | *George Wimpey Canada Ltd. – Moodie Drive (Fallowfield) Quarry (active)* |
| *CP–16* | *Warren Paving & Materials Group Ltd. – Houlahan (Fallowfield) Quarry (active)* |
| *CP–17* | *United Aggregates Ltd. – South Gloucester Quarry (active)* |
| *CP–18* | *Warren Paving & Materials Group Ltd. – Boyce (South Gloucester) Quarry (active)* |
| *CP–19* | *Beaver Asphalt Paving Co. Ltd. – Ottawa (South Gloucester) Quarry (active)* |
| *CP–20* | *Permanent Concrete – Hawthorne Road Quarry (active)* |
| *CP–21* | *Cornwall Sand & Gravel Company – Greely Quarry (active)* |
| *CP–22* | *Francon Division of Canfarge Ltd.– North and South (Francon) Quarries (active)* |
| *CP–23* | *Permanent Concrete – Navan (LeBlanc) Quarry (active)* |
| *CP–24* | *Bertrand & Freres Construction Company Limited – Sarsfield Quarry (active)* |
| *CP–25* | *Steep Rock Calcite – Tatlock Quarry (active)* |

## REGIONAL GEOLOGY

The main geomorphic features of Carleton Place District include the Ottawa Valley to the north and east and the Precambrian highlands of the Canadian Shield to the west. Flat lying plains occur in the eastern part of Carleton Place District.

Glacial overburden varies considerably from nearly absent over the Precambrian highlands, to thin sand deposits in the south and to thick clay deposits along parts of the Ottawa Valley.

Large–scale normal faults trend northwest–southeast across the district (Williams, in prep.). In the main Paleozoic outcrop area, down–dropped fault blocks juxtapose strata that are several hundred metres apart stratigraphically. Although bedrock exposures are generally limited, drillhole data confirm the presence of many of these faults (Williams, in prep.). Smaller–scale faults are common throughout the region, many of which are exposed in quarries.

The Paleozoic strata underlying Carleton Place District consist of Upper Cambrian to Upper Ordovician carbonate and clastic rocks (Figure CP–0–2). The following formations occur within the district (in ascending stratigraphic order): the Covey Hill and Nepean Formations of the Potsdam Group, the March and Oxford Formations of the Beekmantown Group; the Rockcliffe Formation; the Shadow Lake, Gull River, Bobcaygeon, Verulam, and Lindsay Formations of the Ottawa Group; the Billings Formation; the Carlsbad Formation; and the Queenston Formation.

The Upper Cambrian to Lower Ordovician Potsdam Group consists of conglomerates and arkoses of the Covey Hill Formation and the overlying quartz arenites of the Nepean Formation. Only small operations currently utilize this rock for aggregate and dimension stone, although historically the sandstones of the Nepean Formation have been used extensively as building stone in, for example, the Parliament Buildings in Ottawa.

The overlying Lower Ordovician Beekmantown Group consists of two formations: the March and Oxford Formations. The March Formation is transitional between the clastic rocks of the Potsdam Group and the overlying dolostones of the Oxford Formation and consists of alternating beds of quartz arenite and dolostone, with gradations between the two rock types. The most common lithology is a fine–crystalline dolostone which consists of up to 50% medium– to coarse–grained well–rounded quartz grains that "float" in the dolostones. The lower contact of the March Formation is placed at the base of the lowest dolostone bed (Williams, in prep.). The formation thickens from its erosional edge to an average thickness of 20 m in the Ottawa area and even more to the southeast.

The March Formation has been quarried extensively over the years. Large blocks of sandy dolostone were utilized in the construction of the Rideau Canal system in the 1830s and dolostone and sandy dolostone beds were also quarried for building and ornamental stone. In addition to being a source for crushed stone in recent years, the sandy dolostone beds have proven to be an excellent source of skid–resistant aggregate (Rogers, 1980). The principal quarries which extract rock from the formation

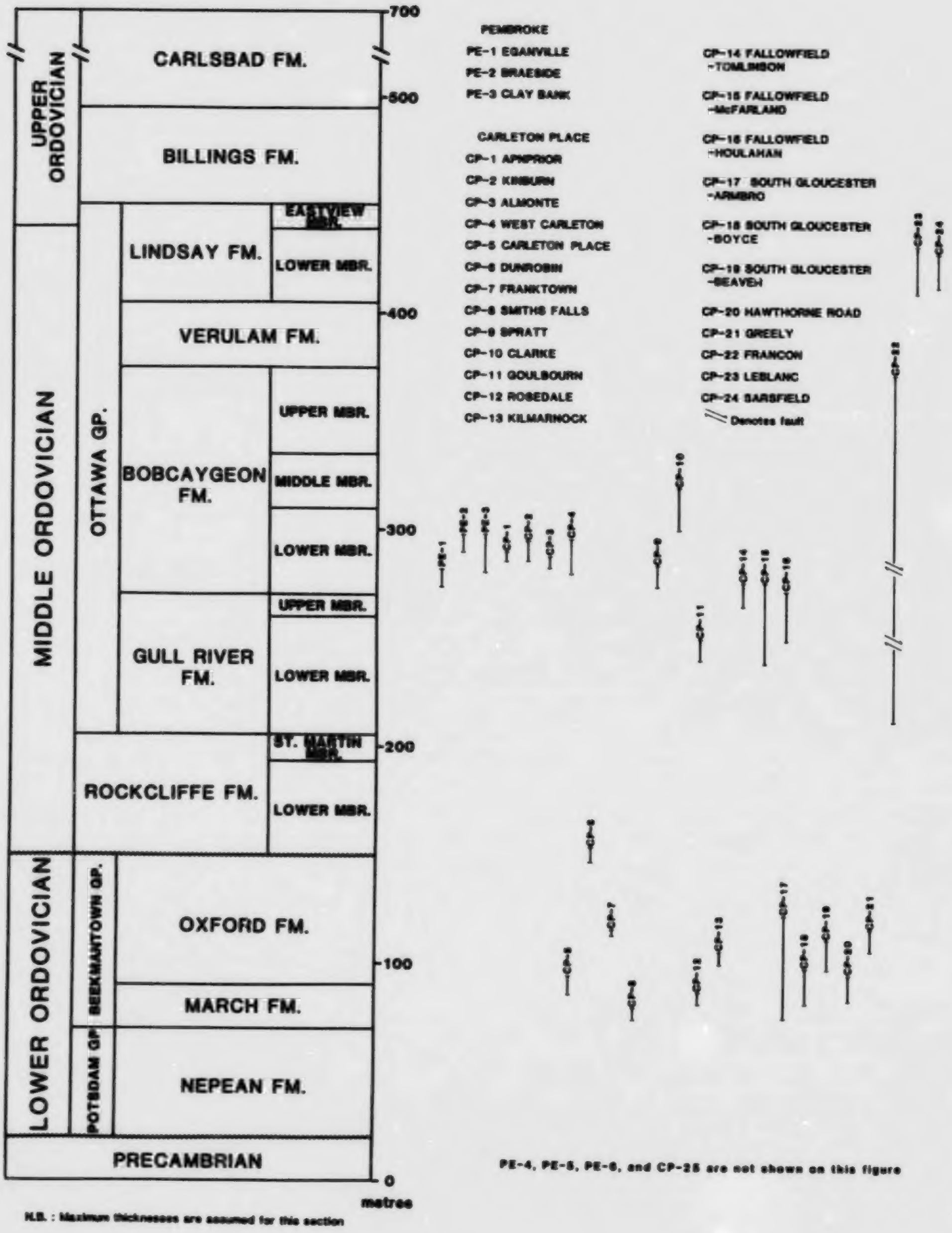

UPPER ORDOVICIAN
MIDDLE ORDOVICIAN
LOWER ORDOVICIAN
OTTAWA GP.
BEEKMANTOWN GP.
POTSDAM GP.
CARLSBAD FM.
BILLINGS FM.
LINDSAY FM.
EASTVIEW MBR.
LOWER MBR.
VERULAM FM.
BOBCAYGEON FM.
UPPER MBR.
MIDDLE MBR.
LOWER MBR.
GULL RIVER FM.
UPPER MBR.
LOWER MBR.
ROCKCLIFFE FM.
ST. MARTIN MBR.
LOWER MBR.
OXFORD FM.
MARCH FM.
NEPEAN FM.
PRECAMBRIAN
700
500
400
300
200
100
0
metres
N.B. : Maximum thicknesses are assumed for this section
PEMBROKE
PE-1 EGANVILLE
PE-2 BRAESIDE
PE-3 CLAY BANK
CARLETON PLACE
CP-1 ARNPRIOR
CP-2 KINBURN
CP-3 ALMONTE
CP-4 WEST CARLETON
CP-5 CARLETON PLACE
CP-6 DUNROBIN
CP-7 FRANKTOWN
CP-8 SMITHS FALLS
CP-9 SPRATT
CP-10 CLARKE
CP-11 GOULBOURN
CP-12 ROSEDALE
CP-13 KILMARNOCK
CP-14 FALLOWFIELD -TOMLINSON
CP-15 FALLOWFIELD -McFARLAND
CP-16 FALLOWFIELD -HOULAHAN
CP-17 SOUTH GLOUCESTER -ARMBRO
CP-18 SOUTH GLOUCESTER -BOYCE
CP-19 SOUTH GLOUCESTER -BEAVEN
CP-20 HAWTHORNE ROAD
CP-21 GREELY
CP-22 FRANCON
CP-23 LEBLANC
CP-24 SARSFIELD
Denotes fault
PE-4, PE-5, PE-6, and CP-25 are not shown on this figure

**Figure CP-0-2. STRATIGRAPHIC COLUMN SHOWING PRINCIPAL QUARRIES OF PEMBROKE AND CARLETON PLACE DISTRICTS.**

include the lower part of the Carleton Place Quarry (CP-5), the Smiths Falls Quarry (CP-8), the Rosedale Quarry (CP-12), the lower parts of the South Gloucester quarries of United Aggregates (CP-17) and Warren Paving (CP-18), and the lower part of the Hawthorne Road Quarry (CP-20). Numerous small quarries, now abandoned, occur throughout the western part of the Carleton Place District.

The Oxford Formation consists of grey-brown, fine-crystalline, medium-bedded dolostones which may vary from microcrystalline to medium-crystalline and occur in thin– to thick–bedded intervals. Scattered, coarse–grained quartz sand and sandy interbeds (up to 30 cm thick), are present in the lower part of the formation. Calcite–filled vugs of varying sizes are common in most intervals; small, white chert nodules are less common. The lower contact of the Oxford Formation is placed at the top of the uppermost sandstone bed in the underlying March Formation (Williams, in prep.). The formation maintains an average thickness of 60 m in Carleton Place District, although it does thin northwestward into the Pembroke District.

The Oxford Formation is quarried for crushed stone across the Carleton Place District. The major producers of aggregate include the Greely Quarry (CP–21), the Kilmarnock Quarry (CP–13), the Carleton Place Quarry (CP–5), the Hawthorne Road Quarry (CP–20), and the South Gloucester quarries of United Aggregates (CP–17), Warren Paving (CP–18) and Beaver Asphalt (CP–19).

Unconformably overlying the Oxford Formation is the Middle Ordovician Rockcliffe Formation. The Rockcliffe Formation is subdivided into two members (Williams, in prep.), a lower clastic and upper carbonate member (Figure CP–0–2). The light grey to green–grey, fine–grained, thin– to thick–bedded, commonly crossbedded, quartz sandstone of the lower member is interbedded with olive green to grey (rarely maroon), laminated shale which commonly contains numerous burrows. The upper St. Martin Member consists of light grey to grey–brown, microcrystalline to fine–crystalline limestone to more commonly coarse– grained, thick–bedded, cross–bedded calcarenites. The very high calcium content of these limestones along the Ottawa River (Williams, in prep.) increases the potential usefulness of these rocks. The uppermost part of the St. Martin Member also contains thin intervals of grey–brown, shaly to silty dolostones. The formation reaches a thickness of 50 m at the extreme eastern end of the district along the Ottawa River although it thins westward to a thickness of 25 m near Arnprior. (The lower member ranges in thickness from 40 to 25 m east to west, while the upper member thins from 10 m in the east to zero where it pinches out west of Ottawa.)

The Rockcliffe Formation is intermittently quarried for crushed stone at the Dunrobin Quarry (CP–6), although several test pits near Carleton Place have been excavated to evaluate the sandier portions of the lower member.

The Middle Ordovician Ottawa Group consists of five formations which, except for the Shadow Lake Formation, are extensively utilized by the limestone industry in Carleton Place District. The Shadow Lake Formation, which overlies the Rockcliffe Formation with a minor disconformity, is a thin (3 m) interval of sandstone and shale which marks the initial deposits of the Ottawa Group.

The Gull River Formation is subdivided into two members (Williams, in prep.): the lower member consists of interbedded dolostone and limestone and the upper member consists of shaly limestone. The dolostones of the lower member are grey–brown to grey–green, fine crystalline, thin to medium bedded, and commonly contain some clastic material ranging in size from mud to sand. Large calcite–filled vugs are common in some beds. The interbedded limestones range from light grey, microcrystalline limestone, commonly with "birdseye" texture, to medium grey, fine– to medium–crystalline limestone. The lower member maintains a uniform thickness of 50 m across the district. The 10 m thick upper member commonly consists of light grey, microcrystalline to fine–crystalline, thin–bedded limestone with shale interbeds. The colonial coral *Tetradium* is very abundant in this member.

The Gull River Formation is quarried for crushed stone in several places around Ottawa. The major producers include the Goulbourn Quarry (CP–11), the Fallowfield Quarries of Tomlinson (CP–14) and of Warren Paving (CP–16), the Moodie Drive Quarry (CP–15) and the lower part of the northern quarry of the Francon Quarry (CP–22). Not all the rock of the lower member can be used for concrete aggregate because of the alkali–reactivity of some of the grey–green dolostone beds (Rogers, 1985).

The Bobcaygeon Formation overlies the Gull River Formation and consists of limestone with varying amounts of shale partings and interbeds. Three members have been identified in the Bobcaygeon Formation (Williams, in prep.); the middle member is characterized by substantially more shale interbeds than the lower and upper members. The lower member consists of light grey, microcrystalline to fine–crystalline, thick– to massive–bedded limestone interbedded with fine– to medium–grained calcarenites. Black chert nodules are common in some beds. Shale partings are very thin and are not present between every bed. The middle member consists of grey, thin– to medium–bedded, fine– to medium–crystalline limestone and fine– to coarse–grained calcarenites interbedded with shale beds up to 2 cm thick. The upper member, which is rarely exposed, consists of grey, fine– to medium–crystalline, thin– to medium–bedded limestone, with rare, thin shale partings. The formation is about 95 m thick with the lower, middle, and upper members maintaining thicknesses of 30, 25 and 40 m, respectively, across the district.

The lower member of the Bobcaygeon Formation is exposed as a caprock at the top of several quarries, including the Fallowfield Quarries (CP–14, 15, 16). It also occurs within the Francon Quarry (CP–22), at the top of the north quarry and within several fault blocks of the south quarry. Several quarries are entirely within the lower member: the Arnprior Quarry (CP–1), the Kinburn Quarry (CP–2), the Almonte Quarry (CP–3), the

West Carleton Quarry (CP–4), the Spratt Quarry (CP–9), and the lower part of the Clarke Quarry (CP–10). The middle member occurs at the top of the Clarke Quarry (CP–10), and within most of the fault blocks in the south quarry of the Francon Quarry (CP–22). The upper member is only exposed in a few of the fault blocks of the south quarry of the Francon Quarry (CP–22). Many smaller, now abandoned quarries also occur within the strata of the formation across the district.

Conformably overlying the Bobcaygeon Formation is the Verulam Formation which consists of interbedded limestones and shales. The limestones range from microcrystalline to medium–crystalline limestone and fine– to coarse–grained calcarenites which occur in thin– to medium–bedded intervals. Beds of coarse fossil debris commonly occur within the limestone beds. The shales are commonly calcareous with abundant fossils and burrows and occur in beds up to 15 cm thick. The formation thickens eastward from 40 to 60 m across the area.

The high shale content and lack of exposures have prohibited any quarrying of the Verulam Formation in Carleton Place District.

The Lindsay Formation is a limestone with thin calcareous shale interbeds, conformably overlying the Verulam Formation. The Lindsay Formation is divisible into two members (Figure CP–0–2): the lower a nodular limestone, and the upper, Eastview Member, a black petroliferous, calcareous shale (Williams, in prep.). The main characteristic of the limestones of the lower member is the nodular texture which is enhanced by thin calcareous shale partings. The thin– to thick–bedded limestones are commonly microcrystalline to medium–crystalline with interbeds of medium– to coarse–grained calcarenites. The upper Eastview Member is a black, calcareous shale that exudes a petroliferous odour from a fresh surface. Across the district the lower and upper members maintain a uniform thickness of 20 m and 10 m respectively.

The limestones of the lower member are quarried for crushed stone in the eastern end of Carleton Place District at the Navan (CP–23), and Sarsfield (CP–24) Quarries. The Eastview Member is not utilized by the limestone industry.

The overlying Upper Ordovician rocks, the Billings, Carlsbad, and Queenston Formations primarily consist of shale, with some limestone in the Carlsbad Formation, and total approximately 300 m of strata. These formations are not currently utilized by the limestone industry, although the red shales of the Queenston Formation are used by the brick industry.

## LIMESTONE INDUSTRIES

The principal limestone industries in Carleton Place District are construction aggregate and the production of calcite chips and fillers from Grenville marble.

The 1986 Ontario Mineral Score reported stone production for the district in 1986 was approximately 6,890,000 tonnes; the majority was used in the construction industry as road, asphalt and concrete aggregate.

Approximately 6,403,000 tonnes of stone were produced in the Regional Municipality of Ottawa–Carleton, some 50% of which was derived from Geo. Wimpey Canada Ltd. – Moodie Drive (Fallowfield) Quarry (CP–15), United Aggregates Ltd. – South Gloucester Quarry (CP–17), Francon Division of Canfarge Ltd. – North and South (Francon) Quarries (CP–22), and R. W. Tomlinson Ltd. – Fallowfield Quarry (CP–14), each producing in excess of 500,000 tonnes per year. The remaining production can be broken down into two groups; those quarries producing between 250,000 and 500,000 tonnes per year which include Spratt Sand and Gravel Ltd. – Spratt Quarry (CP–9), West Carleton Sand and Gravel Inc. – Clarke Quarry (CP–10), Warren Paving & Materials Group Ltd. – Boyce (South Gloucester) Quarry (CP–18), Beaver Asphalt Paving Co. Ltd. – Ottawa (South Gloucester) Quarry (CP–19), and Permanent Concrete – Navan (LeBlanc) Quarry (CP–23) and those quarries producing less than 250,000 tonnes per year which include Thomas Cavanagh Construction Ltd. – Kinburn Quarry (CP–2), West Carleton Quarry (CP–4), and Goulbourn Quarry (CP–11), George Kennedy – Dunrobin Quarry (CP–6), Warren Paving & Materials Group Ltd. – Houlahan (Fallowfield) Quarry (CP–16), Permanent Concrete – Hawthorne Road Quarry (CP–20) and Bertrand & Freres Construction Company Limited – Sarsfield Quarry (CP–24).

Stone production in Lanark County is relatively small in comparison to that reported in the Regional Municipality of Ottawa–Carleton. The total stone production in 1986 in Lanark County amounted to approximately 446,000 tonnes which is derived largely from the Grenville marbles of the Tatlock Quarry of Steep Rock Calcite (CP–25) with minor contribution on an intermittent basis from the following Paleozoic carbonate quarry properties: Thomas Cavanagh Construction Ltd. – Arnprior Quarry (CP–1) and Franktown Quarry (CP–7), R. C. Lyle (Burntlands Aggregates Ltd.) – Almonte Quarry (CP–3), Duffy Road Oiling Ltd. – Carleton Place Quarry (CP–5), Warren Paving & Materials Group Ltd. – Smiths Falls (Dibblee) Quarry (CP–8) and G. Tackaberry & Sons Construction Co. Ltd. – Rosedale Quarry (CP–12) and Kilmarnock Quarry (CP–13).

## CP-1 THOMAS CAVANAGH CONSTRUCTION LTD. — ARNPRIOR QUARRY

### LOCATION AND OWNERSHIP

This quarry, located 8 km south of Arnprior at the Renfrew–Lanark county lines, in Lots 26–27, Concession 9, Pakenham Township, Lanark County (Figure CP–1–1), has been intermittently operated by Thomas Cavanagh Construction Ltd. When visited in 1986, the quarry was inactive and partially flooded. The quarry licence covers an area of 38.2 ha.

### GEOLOGY

Above the water level, 4.0 m of fine– to medium–crystalline, medium–bedded limestones of the lower member, Bobcaygeon Formation are exposed. The quarry has been excavated westward into a low hillside. Glacial overburden varies from 1 to 2 m around the quarry site.

### Geological Section

| | *Thickness* |
|---|---|
| *UNIT 1 Bobcaygeon Formation, lower member* | *4.0m* |
| **Limestone: medium to dark grey, weathers light grey; microcrystalline to fine crystalline, with rare beds medium to coarse crystalline or calcarenitic; medium bedded (20–30 cm), with a thick bed (80 cm) capping quarry face; contacts sharp with rare, very thin shale partings between some beds; very fossiliferous, brachiopods especially abundant in coarser–crystalline beds.** | |
| *Total thickness* | *4.0m* |

### REFERENCES

None

### MAPS

Williams, Wolf and Rae, 1984, OGS Map P.2726

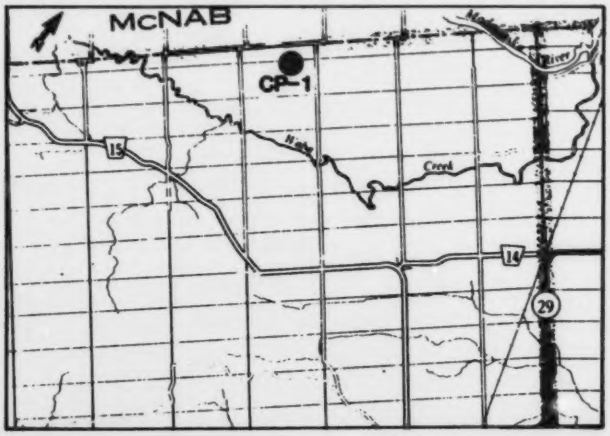


**Figure CP–1–1. LOCATION MAP FOR ARNPRIOR QUARRY.**

## CP-2 THOMAS CAVANAGH CONSTRUCTION LTD. — KINBURN QUARRY

### LOCATION AND OWNERSHIP

The Kinburn Quarry is located 4 km south of the village of Kinburn in Lot 4, Concession 5, West Carleton Township (Fitzroy Ward), Regional Municipality of Ottawa–Carleton (Figure CP–2–1).

The quarry was opened in 1980 by the present owner and operator Thomas Cavanagh Construction Ltd. Stone from the Kinburn Quarry is extracted and processed on an intermittent basis, and a portable crushing plant is set up on site when product stockpiles become exhausted. The quarry licence covers an area of 40.46 ha.

### GEOLOGY

The 9.3 m deep quarry exposes thin–bedded, shaly limestone of the middle member of the Bobcaygeon Formation. In addition to abundant fossils, some of the bedding planes within this quarry display exceptionally large burrows. Glacial overburden around the quarry, which has been excavated southward into a hillside, varies from 1 to 2 m in thickness.

### Geological Section

| | *Thickness* |
|---|---|
| *UNIT 1 Bobcaygeon Formation, middle member* | *9.3m* |
| **Limestone: medium grey to grey–brown, weathers light grey–brown to light brown; fine to medium crystalline with some beds coarse calcarenitic and bioclastic; medium bedded (10–20 cm), with sharp and planar contacts marked by 1–2 cm thick, dark grey, shale partings; very fossiliferous with abundant brachiopods, trilobites and large burrows on bedding planes.** | |
| *Total thickness* | *9.3m* |

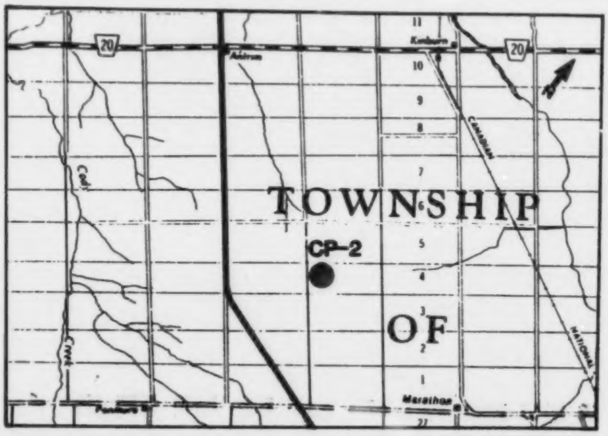


**Figure CP–2–1. LOCATION MAP FOR KINBURN QUARRY.**

### REFERENCES

None

### MAPS

None

## CP-3 R.C. LYLE (BURNTLANDS AGGREGATE LTD.) — ALMONTE QUARRY

### LOCATION AND OWNERSHIP

This quarry, located 3 km northeast of Almonte in Lots 16–17, Concession 12, Ramsay Township, Lanark County (Figure CP-3-1), has been operated by R. C. Lyle (Burntlands Aggregate Ltd.). When visited in 1986, the quarry was inactive and partially filled with water. The quarry licence covers an area of 74.87 ha.

### GEOLOGY

The 5.0 m deep quarry exposes fine–crystalline, thin– to medium–bedded limestones of the lower member of the Bobcaygeon Formation. The description below was recorded in 1982 before the quarry filled with water. Glacial overburden around the quarry is shallow, generally less than 1 m thick.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 1 Bobcaygeon Formation, lower member* | *5.0m* |
| Limestone: medium to dark grey, light grey in lowest metre, weathers medium grey, to grey–brown at top; fine to coarse crystalline with microcrystalline beds present at base of quarry face; thin to medium bedded (5– 25 cm), with some thin shale partings between beds; small patches of calcite crystals ("birdseye" texture) common in microcrystalline beds; fossiliferous, especially with large colonial corals in upper part of quarry. | |
| *Total thickness* | *5.0m* |

### REFERENCES

Williams, in prep., Appendix 1 – Section LQ AR–1

### MAPS

Williams, Wolf and Rae, 1984, OGS Map P.2726

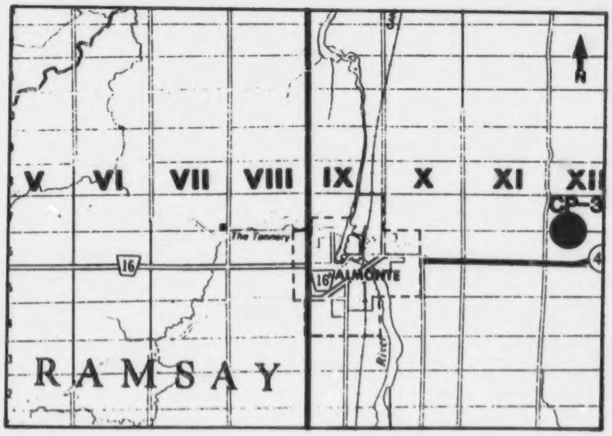


Figure CP-3-1. LOCATION MAP FOR ALMONTE QUARRY.

## CP-4 THOMAS CAVANAGH CONSTRUCTION LTD. — WEST CARLETON QUARRY

### LOCATION AND OWNERSHIP

The West Carleton Quarry is located 6 km northeast of Almonte on Highway 44 in Lots 14 and 15, Concession 11, West Carleton Township (Huntley Ward), Regional Municipality of Ottawa–Carleton (Figure CP-4-1). The quarry, originally opened by Metcalf Construction, was subsequently purchased by Thomas Cavanagh Construction Limited in 1971. Stone from the West Carleton Quarry was used in the construction of Highway 17. The quarry is licensed for an area of 121.18 ha.

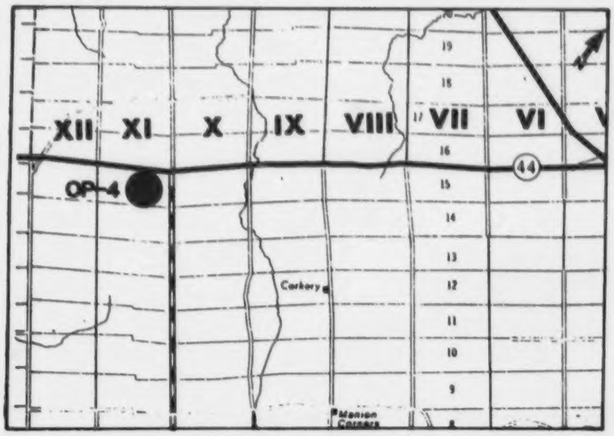


Figure CP-4-1. LOCATION MAP FOR WEST CARLETON QUARRY.

### GEOLOGY

The 16.5 m deep quarry exposes limestones of the lower member of the Bobcaygeon Formation in two lifts which have been excavated southwestward into a hillside. Glacial overburden around the quarry site varies from 1 m to 2 m in thickness.

### Geological Section

*Thickness*

*UNIT 13 Bobcaygeon Formation, lower member 1.6m*

Limestone: medium to dark grey, weathers same; very fine to fine crystalline; thin bedded (5-10 cm), with sharp and irregular contacts; very fossiliferous with numerous large fossils (corals and stromatoporoids) producing a rubbly weathered surface; lower contact of unit sharp at base of thin shale bed.

*UNIT 12 Bobcaygeon Formation, lower member 1.1m*

Limestone; medium to dark grey, weathers medium grey; interbedded microcrystalline to fine-crystalline and medium- to coarse-grained calcarenites; medium bedded (15-20 cm) with sharp planar contacts; moderately fossiliferous; lower contact of unit sharp and planar.

*UNIT 11 Bobcaygeon Formation, lower member 1.5m*

Limestone: medium to dark grey, weathers same; very fine crystalline; thin bedded (5-10 cm) with thin shale partings, with sharp and slightly undulating contacts; lower contact of unit sharp and planar at base of 2 cm shale bed.

*UNIT 10 Bobcaygeon Formation, lower member 2.2m*

Limestone: dark grey, weathers light to medium grey; microcrystalline; thick bedded (40-50 cm), with sharp and planar contacts; sparsely fossiliferous; lower contact of unit sharp.

*UNIT 9 Bobcaygeon Formation, lower member 0.5m*

Limestone: light grey, weathers lighter grey; coarse-grained calcarenite; single bed; lower contact of unit sharp and planar.

*UNIT 8 Bobcaygeon Formation, lower member 1.6m*

Limestone: dark grey, weathers same; very fine crystalline; medium bedded (10-15 cm) with sharp and planar contacts; sparsely fossiliferous; lower contact of unit sharp and planar.

*UNIT 7 Bobcaygeon Formation, lower member 1.3m*

Limestone: medium to dark grey, weathers same; fine to medium crystalline; medium bedded (20- 25 cm), although weathers into thinner beds; moderately fossiliferous; lower contact of unit sharp and irregular; top of lower lift at top of unit.

*UNIT 6 Bobcaygeon Formation, lower member 1.3m*

Limestone: light grey, weathers same; very coarse-grained calcarenite which fines upwards to coarse grained in places; single bed composed of large scale crossbeds, with sets of crossbeds separated by thin shale partings; lower contact of unit sharp and planar.

*UNIT 5 Bobcaygeon Formation, lower member 1.5m*

Limestone: medium to dark grey, weathers same; very fine to fine crystalline; thin to medium bedded (8-15 cm), with sharp and planar contacts; lower contact of unit sharp at top of 2 cm thick shaly limestone bed.

*UNIT 4 Bobcaygeon Formation, lower member 1.4m*

Limestone: dark grey, weathers light grey; microcrystalline to very fine crystalline; thin bedded (8-10 cm) with sharp and planar contacts; lower contact of unit sharp and irregular.

*UNIT 3 Bobcaygeon Formation, lower member 0.7m*

Limestone: dark grey, weathers light brown; fine crystalline; single bed with irregular contacts; slump structures present in places; lower contact of unit sharp and irregular.

*UNIT 2 Bobcaygeon Formation, lower member 0.8m*

Limestone: dark grey, weathers light to medium brown; very fine crystalline; thin bedded (8-10 cm), in regular beds with sharp and planar contacts; lower contact of unit sharp and planar.

*UNIT 1 Bobcaygeon Formation, lower member 1.0m*

Limestone: dark grey, weathers light brown to grey-brown; very fine to fine crystalline; medium bedded (15 cm), with rare thin shale partings and sharp, planar contacts; moderately fossiliferous.

*Total thickness 16.5m*

### QUARRY OPERATION

The property is excavated on two lifts of about 8.2 m each. The first lift has an area of approximately 10 ha and is not currently mined. The second lift is actively mined toward the southwest.

### PROCESSING

The stone is hard and is crushed by either a 36 in. x 45 in. Cedarapids impeller or a Cedarapids Commander crusher. A Cat 988B loader is used to haul blasted stone to the crushing plant. The quarry produced granular stone, tile bed and HL products in 1986.

### REFERENCES

Williams, in prep., Appendix 1 – Section LQ AR-2

### MAPS

Williams, Wolf and Rae, 1984, OGS Map P.2726

## CP-5 DUFFY ROAD OILING LTD. – CARLETON PLACE QUARRY

### LOCATION AND OWNERSHIP

This quarry, located 1 km northeast of Carleton Place in Lot 2, Concession 8, Ramsay Township, Lanark County (Figure CP-5-1), is operated intermittently by Duffy Road Oiling Ltd. The quarry licence covers an area of 62.63 ha.

### GEOLOGY

The 8.8 m deep quarry exposes the contact between the sandstones and sandy dolostones of the March Forma-

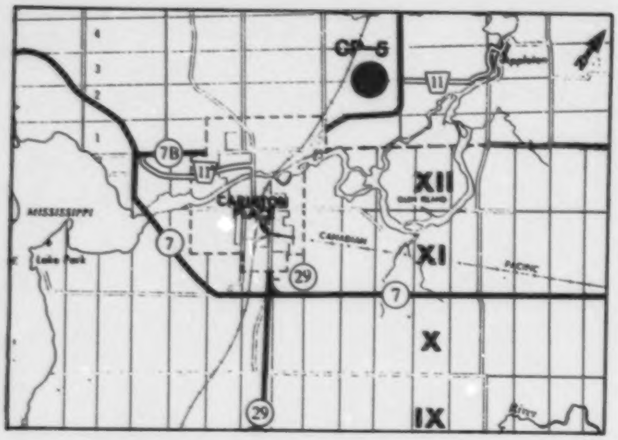

CP-6
11
7B
7
29
XII
XI
X
IX
MISSISSIPPI
CARLETON PLACE
Lake Park
Appleton
CANADIAN
PACIFIC
4
3
2
1

Figure CP-5-1. LOCATION MAP FOR CARLETON PLACE QUARRY.

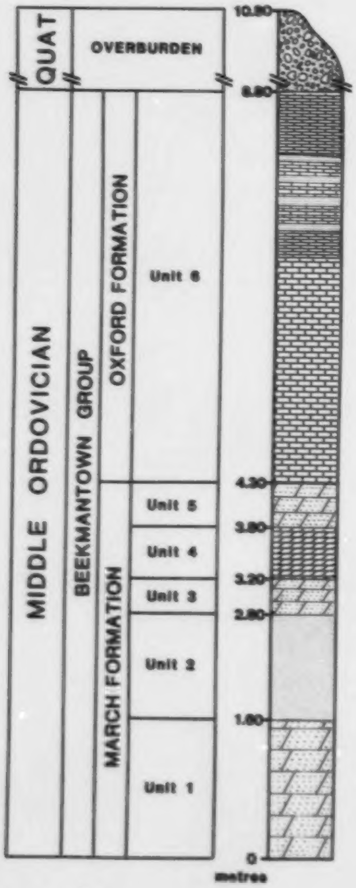

QUAT
OVERBURDEN
MIDDLE ORDOVICIAN
BEEKMANTOWN GROUP
OXFORD FORMATION
MARCH FORMATION
Unit 6
Unit 5
Unit 4
Unit 3
Unit 2
Unit 1
10.80
8.80
4.30
3.80
3.20
2.80
1.60
0
metres

Figure CP-5-2. STRATIGRAPHIC COLUMN FOR CARLETON PLACE QUARRY.

tion and the dolostones of the overlying Oxford Formation (Figure CP-5-2). Glacial overburden around the quarry varies from 1 m to 2 m in thickness.

### Geological Section

| | | *Thickness* |
|---|---|---|
| *UNIT 6* | *Oxford Formation* | *4.5m* |

Dolostone: light grey-brown to light brown, weathers light brown to buff; fine crystalline with rare, thin intervals of medium to coarse grained sandy dolostones; thin to medium bedded (5-20 cm), with sharp and planar contacts; some calcite-filled vugs present in lowest 2 m of unit; lower contact of unit sharp and planar.

| | | |
|---|---|---|
| *UNIT 5* | *March Formation* | *0.5m* |

Sandy dolostone: light grey-brown, weathers buff; fine- crystalline dolostone with abundant medium- to coarse-grained quartz grains; medium bedded (25 cm), with sharp and planar contacts; calcite-filled vugs common; lower contact of unit sharp and planar.

| | | |
|---|---|---|
| *UNIT 4* | *March Formation* | *0.6m* |

Dolostone: medium to dark grey, weathers light brown; fine crystalline; thin bedded (5-10 cm) with sharp and planar contacts; calcite-filled vugs common; lower contact of unit sharp and planar.

| | | |
|---|---|---|
| *UNIT 3* | *March Formation* | *0.4m* |

Sandy dolostone: light to medium grey-brown, weathers medium grey; fine-crystalline dolostone with abundant coarse-grained quartz grains; medium bedded (20 cm); calcite-filled vugs common; lower contact of unit sharp and planar.

| | | |
|---|---|---|
| *UNIT 2* | *March Formation* | *1.2m* |

Sandstone: white, weathers white with light reddish-brown stains; medium-grained, well-sorted, well-rounded quartz grains; calcareous cement; medium bedded (15-25 cm) with small to medium scale crossbeds common in most beds; small burrows present in some beds; lower contact of unit sharp and planar.

| | | |
|---|---|---|
| *UNIT 1* | *March Formation* | *1.6m* |

Sandy dolostone: medium grey, weathers light to medium grey; fine crystalline with medium- to coarse-grained, well-rounded quartz grains.

| | |
|---|---|
| *Total thickness* | *8.8m* |

### REFERENCES

Goudge, 1938, p.114
Hewitt, 1964a, p.18
Rogers, 1980, p.36-38
Williams, in prep., Appendix 1 - Section LQ CA-4

### MAPS

Williams and Wolf, 1984a, OGS Map P.2725

## CP-6 GEORGE KENNEDY — DUNROBIN QUARRY

### LOCATION AND OWNERSHIP

This small quarry, located 3 km northeast of the hamlet of Dunrobin, in Lot 1, Concession 5, West Carleton Township (Torbolton Ward), Regional Municipality of

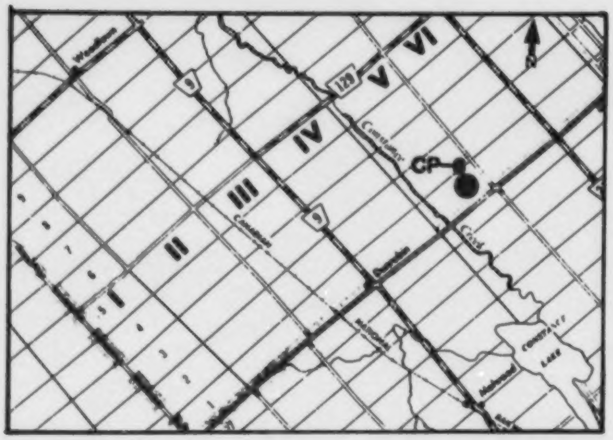


Figure CP-6-1. LOCATION MAP FOR DUNROBIN QUARRY.

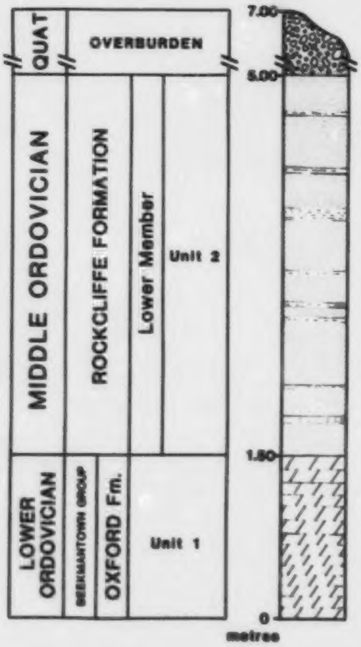


Figure CP-6-2. STRATIGRAPHIC COLUMN FOR DUNROBIN QUARRY.

Ottawa-Carleton (Figure CP-6-1), has been operated intermittently over the last several years. The quarry is licensed for an area of 6.47 ha.

### GEOLOGY

The 5.0 m deep quarry exposes the contact between the very fine-crystalline, medium-bedded dolostones of the Lower Ordovician Oxford Formation and the fine-grained, thin- to medium-bedded sandstones of the Middle Ordovician Rockcliffe Formation (Figure CP-6-2). A northwest-southeast trending fault is exposed along the southwest face of the quarry. Glacial overburden around the quarry varies from 1 m to 2 m in thickness.

#### Geological Section

| *Northeast of Fault* | *Thickness* |
|---|---|
| *UNIT 2 Rockcliffe Formation, lower member* | *3.5m* |
| Sandstone and shale: light grey-green to light brown sandstone with dark green shale, weathers light grey- green; fine-grained sandstone with coarse-grained intervals at base of unit; slightly calcareous cement; thin to medium bedded (5-20 cm) with thin (5 cm) shale interbeds; rare burrows in sandstone and along bedding planes; lower contact of unit sharp with irregular erosional surface. | |
| *UNIT 1 Oxford Formation* | *1.5m* |
| Dolostone: medium grey, weathers buff to light reddish brown; very fine crystalline; medium bedded (15-20 cm). | |
| *Total thickness* | *5.0m* |

### REFERENCES

Williams, in prep., Appendix 1 - Section LQ OT-6

### MAPS

Williams, Rae and Wolf 1984, OGS Map P.2716

## CP-7 THOMAS CAVANAGH CONSTRUCTION LTD. — FRANKTOWN QUARRY

### LOCATION AND OWNERSHIP

This small quarry, located 4 km northeast of Franktown, in Lot 16, Concession 2, Beckwith Township, Lanark County (Figure CP-7-1), has been operated intermittently by Thomas Cavanagh Construction Ltd.. The quarry licence covers an area of 20.6 ha.

### GEOLOGY

The quarry was partially flooded when visited in 1986 and only 1.7 m of dolostones of the Oxford Formation were exposed. Glacial overburden around the quarry is generally less than 1 m thick.

#### Geological Section

| | *Thickness* |
|---|---|
| *UNIT 1 Oxford Formation* | *1.7m* |
| Dolostone: medium grey to light brown, weathers light grey to buff; fine crystalline; thin bedded (5-10 cm). | |
| *Total thickness* | *1.7m* |

### REFERENCES

Williams, in prep., Appendix 1 - Section LQ CA-3

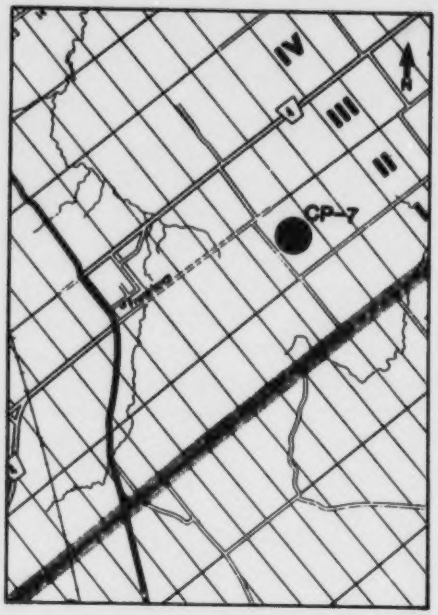


Figure CP-7-1. LOCATION MAP FOR FRANKTOWN QUARRY.

### MAPS

Williams and Wolf, 1984a, OGS Map P.2725

## CP-8 WARREN PAVING & MATERIALS GROUP LTD. – SMITHS FALLS (DIBBLEE) QUARRY

### LOCATION AND OWNERSHIP

This large quarry, located 1 km north of Smiths Falls in Lots 27–28, Concession 5, Montague Township, Lanark County (Figure CP-8-1), has been operated intermittently by Dibblee Construction Co. Ltd. (a subsidiary of Warren Paving & Materials Group Ltd.), for many years. The quarry licence covers an area of 84.2 ha.

### GEOLOGY

The quarry contains two lifts, of which the lower is almost completely filled with water. Recent excavations have been carried out along the east face of the upper lift. A total of 5.2 m of sandy dolostone, dolostone, and sandstone of the March Formation is exposed in the quarry. Glacial overburden around the quarry is about 1–2 m thick.

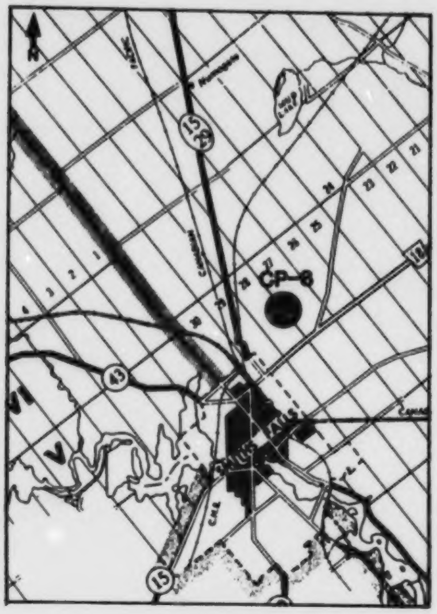


Figure CP-8-1. LOCATION MAP FOR SMITHS FALLS (DIBBLEE) QUARRY.

### Geological Section

*Thickness*

*UNIT 6 March Formation* *2.3m*

Sandy dolostone: light grey to light grey-brown, weathers light grey-brown; fine crystalline with abundant medium- to coarse-grained, well- rounded, well-sorted quartz grains; thin to medium bedded (5-25 cm) with sharp and planar contacts; abundant calcite-filled vugs in some beds; fossiliferous with accumulations of gastropods on some bedding planes; lower contact of unit is sharp and planar.

*UNIT 5 March Formation* *0.5m*

Sandstone: light grey to light green, weathers same; medium grained, with well-sorted, well-rounded quartz grains; calcareous cement; medium bedded (25 cm); lower contact of unit is sharp.

*UNIT 4 March Formation* *0.5m*

Sandy dolostone: light grey, weathers light grey-brown; fine crystalline with coarse-grained, well-rounded, well-sorted quartz grains; thin bedded (5-8 cm); lower contact of unit is covered.

*UNIT 3 March Formation* *0.4m*

Covered interval.

*UNIT 2 March Formation* *0.8m*

Sandy dolostone: light brown to light grey-brown, weathers light grey-brown; fine crystalline with medium- to coarse- grained, well-rounded, well-sorted quartz grains; thin to medium bedded (5-20 cm), with sharp and planar contacts; calcite-filled vugs present in some beds; lower contact of unit sharp and planar; top of lower lift at top of the unit.

*UNIT 1 March Formation* *0.7m*

Dolostone: medium grey, weathers light to medium grey; fine crystalline; thin bedded (5–8 cm); calcite-filled vugs present, base of unit at water level.

*Total thickness* *5.2m*

### REFERENCES

Goudge, 1938, p.118
Hewitt, 1964a, p.19
Rogers, 1980, p.63
Williams, in prep., Appendix 1 – Section LQ PE–4

### MAPS

Williams and Wolf, 1984b, OGS Map P.2724

## CP–9 SPRATT SAND AND GRAVEL LTD. — SPRATT QUARRY

### LOCATION AND OWNERSHIP

The Spratt Sand and Gravel Ltd. head office, processing plant and quarry operations are located 5 km northwest of Stittsville in Lots 2–5, Concession 2, West Carleton Township (Huntley Ward), Regional Municipality of Ottawa–Carleton (Figure CP–9–1).

In 1915 J. Howard Spratt began selling gravel from a deposit on his farm; at that time the gravel was hand loaded and delivered in horse–drawn wagons. The first truck (a Beaver), and shovel (3/4 yd. Austin Western "Badger"), were purchased in 1920 and 1943, respectively, and in the 1920s the first stationary screening facility was used to process gravel. In 1934 the business was taken over by George Spratt, son of J. Howard Spratt, and in 1956 the company was incorporated as Spratt Sand and Gravel Ltd. In 1965 Charles and John Spratt, grandsons of the founder, joined the company. The land containing the limestone quarry was purchased by Spratt Sand and Gravel in 1961; the quarry itself was opened in 1975. The quarry is licensed for 40.46 ha.

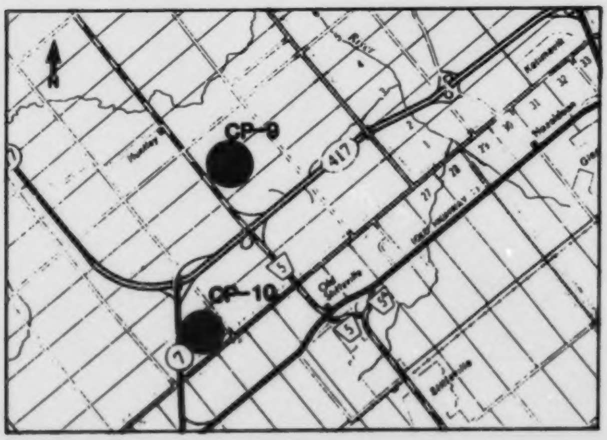


**Figure CP-9-1. LOCATION MAP FOR SPRATT QUARRY.**

Spratt Sand and Gravel markets a wide variety of products. Quality control is maintained by a full–time technician at a laboratory attached to the head office; the laboratory is equipped to carry out gradation, magnesium sulphate soundness loss, colour plate, mortar strength and Proctor tests.

### GEOLOGY

The 11.3 m deep quarry exposes medium to thick–bedded medium– to coarse–crystalline limestones of the lower member of the Bobcaygeon Formation. Glacial overburden around the quarry varies from 1 m to 2 m.

#### Geological Section

*Thickness*

*UNIT 6 Bobcaygeon Formation, lower member* *4.8m*

Limestone: light to medium grey, weathers light grey; medium to coarse crystalline and calcarenitic; medium to thick bedded (20–50 cm), with contacts commonly stylolitic; fossiliferous with corals and brachiopods most abundant; lower contact of unit is sharp and planar.

*UNIT 5 Bobcaygeon Formation, lower member* *1.3m*

Limestone: dark grey, weathers light blue-grey; very fine crystalline; thin to medium bedded (5–15 cm) with thin shaly partings common between beds; fossiliferous with brachiopods abundant; lower contact of unit sharp and stylolitic.

*UNIT 4 Bobcaygeon Formation, lower member* *0.5m*

Limestone: light to medium grey, weathers light grey; medium to coarse crystalline and calcarenitic; single bed; black chert in 5 cm thick interval at top of unit; fossiliferous with corals and brachiopods most abundant; lower contact of unit sharp and stylolitic.

*UNIT 3 Bobcaygeon Formation, lower member* *0.3m*

Limestone: light grey, weathers same; fine crystalline, with medium– to coarse–crystalline interbeds up to 5 cm thick; single bed; fossiliferous with abundant brachiopods; lower contact of unit sharp and stylolitic.

*UNIT 2 Bobcaygeon Formation, lower member* *0.3m*

Limestone: light to medium grey, weathers light grey, medium to coarse crystalline; single bed; fossiliferous with some corals and brachiopods; lower contact of unit sharp and planar.

*UNIT 1 Bobcaygeon Formation, lower member* *4.1m*

Limestone: dark grey, weathers medium grey with blue–grey tones; microcrystalline to very fine crystalline; thin to medium bedded (5–25 cm) with thin shale partings commonly present between beds; fossiliferous with brachiopods most common.

*Total thickness* *11.3m*

### QUARRY OPERATION

The quarry is excavated on two lifts of 5.2 m and 6.1 m, and has an annual production capacity of approximately 450,000 tonnes. Drilling is performed by the company and blasting is contracted. The blasting conditions are generally wet; AN/FO is used as much as possible. The top lift has a 1 m thick capstone layer which requires a 2.1 m x 2.4 m drill pattern and 102 mm diameter holes to achieve good blast fragmentation. The finely broken stone lightens the load on the primary crusher (at quarry floor), and is more suitable for belt conveyor transfer. Armour and gabion stone are rarely produced during blasting and there is little demand for these products in the area.

## PROCESSING

The process flow sheet for the plant is shown on Figure CP-9-2. The blasted stone is loaded by a Cat 980C loader (6 yd.) and hauled by two Euclid R-22 Rock Trucks to the primary crusher, a portable 36 in. x 52 in. Cedarapids double impeller crusher stationed on the quarry floor. The crushed stone is transferred 800 m by a 36 in. field conveyor at 400 tonnes/hr. to a 150 ft. x 30 in. radial stacker producing a -6 in. surge pile. Below the surge pile a 36 m reclaim tunnel equipped with two 36 in. feeders transfers the stone to a 30 in. belt which feeds two 4 ft. x 16 ft. double-deck Dillon screens, producing Granular "A" or stone dust to storage bins, and +7/8 in. oversize. Secondary crushing of the oversize stone is by a single impeller impact crusher feeding the two double-deck Dillon screens. The Granular "A & B" and stone dust products are conveyed and stockpiled. Clear stone and raw sand are conveyed to the washing plant and fed to two 5 ft. x 14 ft. triple-deck Dillon wash screens producing 3/4 in. clear, 1/2 in. clear and 3/8 in. clear to truck bins. The -1/4 in. sand is sent to a Wemco Classifier producing concrete fine aggregate and masonry mortar sand. These products are sent to dewatering screws and stockpiled by two 120 ft. x 24 in. radial stackers. Waste products and extracted water are sent to a cyclone classifier and then to a settling pond. Adjustments to the screening processes and complex blending allow a wide range of products to be marketed.

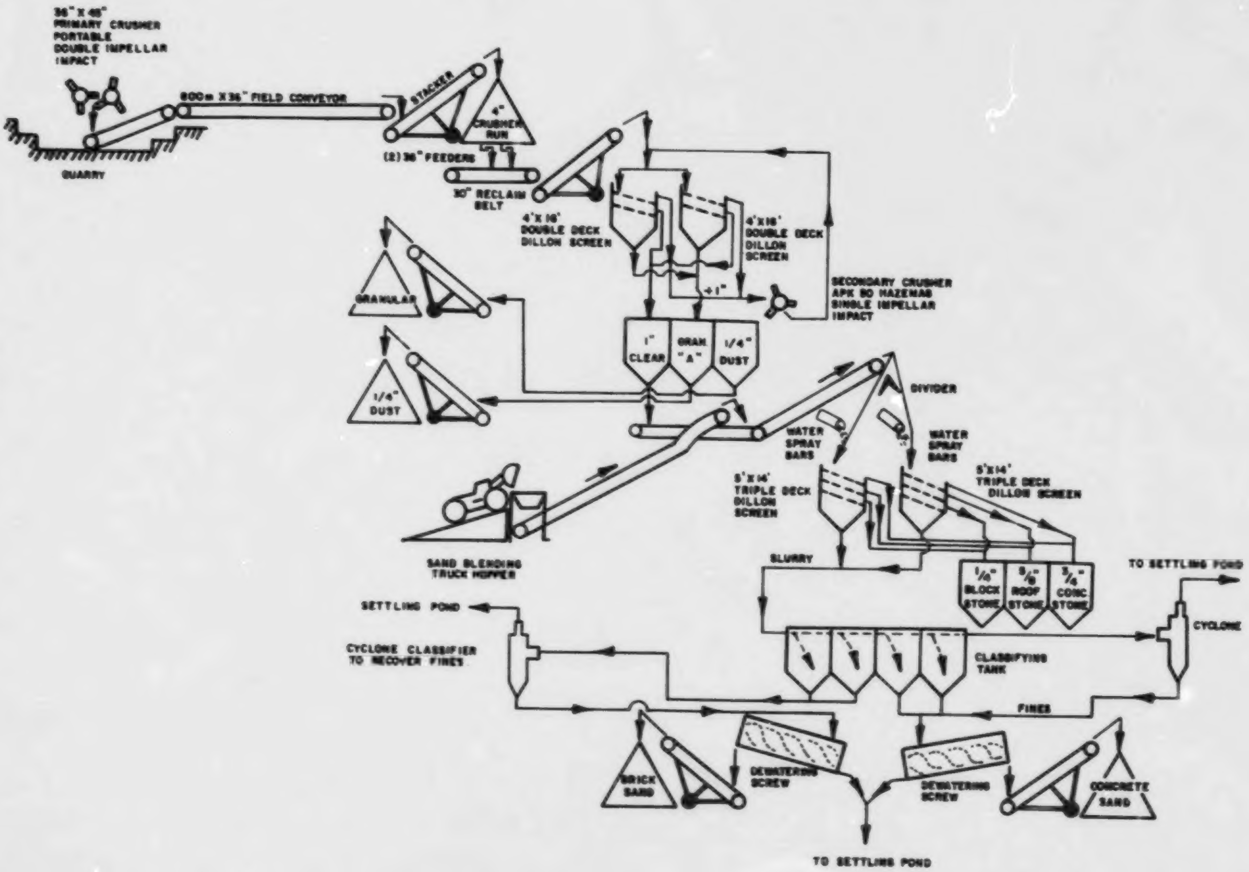

36" X 48"
PRIMARY CRUSHER
PORTABLE
DOUBLE IMPELLAR
IMPACT
QUARRY
800m X 36" FIELD CONVEYOR
STACKER
4"
CRUSHER
RUN
(2) 36" FEEDERS
30" RECLAIM
BELT
4'X 16'
DOUBLE DECK
DILLON SCREEN
4'X16'
DOUBLE DECK
DILLON
SCREEN
+1"
SECONDARY CRUSHER
APK 80 HAZEMAG
SINGLE IMPELLAR
IMPACT
GRANULAR
1/4"
DUST
1"
CLEAR
GRAN
"A"
1/4"
DUST
DIVIDER
WATER
SPRAY
BARS
WATER
SPRAY
BARS
5'X14'
TRIPLE DECK
DILLON
SCREEN
5'X14'
TRIPLE DECK
DILLON SCREEN
SAND BLENDING
TRUCK HOPPER
SLURRY
1/4"
BLOCK
STONE
3/8"
ROOF
STONE
3/4"
CONC
STONE
TO SETTLING POND
SETTLING POND
CYCLONE
CYCLONE CLASSIFIER
TO RECOVER FINES
CLASSIFYING
TANK
FINES
BRICK
SAND
DEWATERING
SCREW
DEWATERING
SCREW
CONCRETE
SAND
TO SETTLING POND

**Figure CP-9-2. PROCESS FLOW SHEET FOR SPRATT QUARRY.**

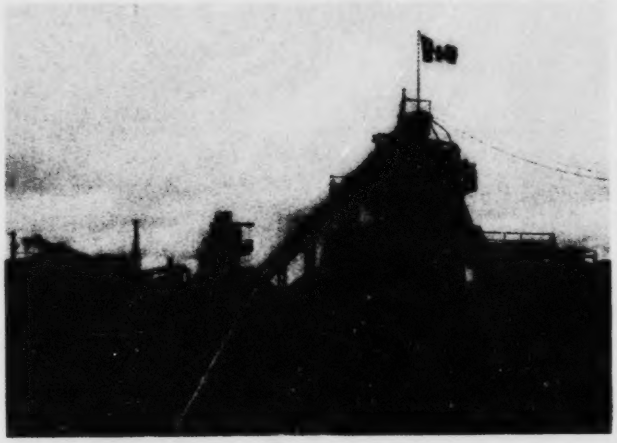


Photo CP-9-1. WASH PLANT TOWER (FOREGROUND) AND SECONDARY CRUSHING SCREENING (BACKGROUND) AT THE SPRATT QUARRY.

### PRODUCTS

#### Group 1

Blasted Rock
Crusher Run Screenings
Crusher Run 6 in. Granular "C"
Crusher Run 4 in. Granular "B"
Crusher Run 2 in. Granular "B"
Crusher Run 5/8 in. Granular "A"
Crusher Run 3/4 in. Granular "A"

#### Group 2

Graded Washed 3/4 in. Concrete Stone
Graded Washed 1/2 in. Concrete Stone
Graded Washed 3/8 in. Concrete Stone
Graded Washed 3/8 in. Roofing
Graded Washed 5/8 in. Roofing
HL3 Asphalt Stone
HL5 Asphalt Stone
HL6 Asphalt Stone
Surface Treatment Stone

#### Group 3

Washed Classified Concrete Sand
Washed Classified Plaster Sand
Washed Classified Masonry Sand
Screened Bedding Sand
Washed Winter Road Grit
Blended Asphalt Sand
Sand fill
Quarry Strippings
Sand fill Class "C"
Pickled Sand

#### Group 4

Clear Washed 5/16 in.
Clear Washed 3/8 in.
Clear Washed 5/8 in.
Clear Washed 3/4 in.
Clear Screened 1/4 in.

### REFERENCES

Williams, in prep., Appendix 1 – Section LQ OT–1

### MAPS

Williams, Rae and Wolf, 1984, OGS Map P.2716

## CP–10 WEST CARLETON SAND AND GRAVEL INC. — CLARKE QUARRY

### LOCATION AND OWNERSHIP

The Clarke Quarry is located 3 km west of Stittsville in Lots 1 and 2, Concession 2, West Carleton Township (Huntley Ward), Regional Municipality of Ottawa–Carleton (Figure CP–10–1).

The quarry was first opened by H. J. McFarland Construction to supply aggregates for construction of Hwy. 417. In 1979 the quarry was purchased by West Carleton Sand and Gravel Inc. and is currently licensed for an area of 62.72 ha.

### GEOLOGY

The presence of a northwest trending fault system in the 10.0 m deep quarry results in a total exposure of 20.0 m of limestones of the lower and middle members of the Bobcaygeon Formation. Several individual faults combine to produce a total down–throw of approximately 9 m to the northeast. In addition, the fault block northeast of the fault system dips northwards at 10°

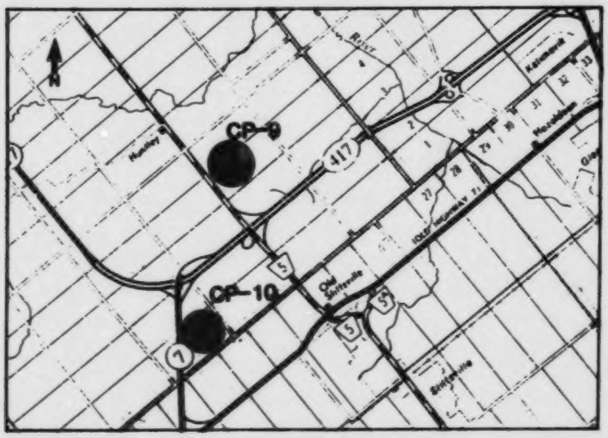


Figure CP-10-1. LOCATION MAP FOR CLARKE QUARRY.

Within the fault system, and well displayed on the west face of the quarry, extensive rotation and fracturing of fault blocks has produced a complex exposure. In addition to high angle normal faults which dip northeast at about 80°, a lower angle irregular fault plane appears in one of the fault blocks. Veins of calcite appear sporadically along some of the fault planes.

The contact between the lower and middle members of the Bobcaygeon Formation is exposed at the south end of the fault block northeast of the main fault system in the quarry. The contact disappears into the quarry floor to the north as these beds are dipping northwards at about 10°. The remainder of the quarry faces, northeast of the fault system, consist of thin–bedded, shaly limestone of the middle member.

Thicker bedded fine– to medium–crystalline limestone of the lower member of the Bobcaygeon Formation is exposed to the southwest and within the fault zone.

Glacial overburden around the quarry varies from 1–4 m in thickness.

### Geological Section

| | *Thickness* |
|---|---|
| *UNIT 2 Bobcaygeon Formation, middle member* | *10.0m* |

Limestone, with shale partings: light to medium grey, weathers light grey; fine to medium crystalline; thin to medium bedded (5–20 cm) with shale partings up to 2 cm thick present between most beds; fossiliferous with brachiopods and corals most abundant; lower contact of unit is sharp and planar at base of shaly limestone.

| | |
|---|---|
| *UNIT 1 Bobcaygeon Formation, lower member* | *10.0m* |

Limestone: medium grey, weathers light to medium grey, with a blue–grey tinge in places; microcrystalline to very fine crystalline to rarely medium crystalline; medium bedded (20–30 cm) with some thicker (40–60 cm) beds scattered throughout unit; sparsely fossiliferous.

| | |
|---|---|
| *Total section thickness* | *20.0m* |
| *Total quarry depth* | *10.0m* |

### QUARRY OPERATION

The quarry is presently advancing to the west on a single lift of about 10 m and the disturbed area is approximately 5 ha. Overburden is used to construct berms, or is stockpiled.

Drilling and blasting is contracted; a 2.4 m x 2.4 m pattern is used with 7.6 cm diameter holes. In some sections of the quarry drilling and blasting is hindered by structurally complex ground. Amex II (AN/FO) and 40% Forcite are used as explosives, initiated by electric delay caps. All blasts are monitored for vibration levels.

### PROCESSING

A Komatsu 500 loader (5.5 yd.) is used to load two 35–ton Euclid trucks with blasted stone. A 43 in. x 40 in. Cedarapids single impeller crusher is used for primary breaking, the stone leaving the crusher at about –4 in. and feeding an Assinck 6 ft. x 20 ft. triple–deck screening plant. To make 3/4 in. clear stone, the screens are set to feed –4 in. plus 1 in. oversize material to a 30 in. x 30 in. New Holland (1939) impactor crusher and 3/4 in. clear and Granular "A" to stockpiles. The stone leaving the New Holland secondary crusher is returned to the Assinck screening plant. If desired, a crusher–run product can also be scalped from the screening plant surge

**Photo CP-10-1. CRUSHING/SCREEN FACILITIES AT THE CLARKE QUARRY (LOOKING SOUTH).**

bin. A Volvo 4600 (4 yd.) loader is used for stockpiling and truck loading.

### PRODUCTS

Gabion Stone 4 in. and 8 in.
Granular "A", "B" and "C"
3/4 in. Clear Concrete Stone
1 in. Septic or Weeping Bed Stone
HL3

### REFERENCES

Williams, in prep., Appendix 1 – Section LQ OT–2.

### MAPS

Williams, Rae and Wolf, 1984, OGS Map P.2716

## CP–11 THOMAS CAVANAGH CONSTRUCTION LTD. — GOULBOURN QUARRY

### LOCATION AND OWNERSHIP

The Goulbourn Quarry is located 4 km northwest of the village of Munster, in Lot 11, Concession 8, Goulbourn Township, Regional Municipality of Ottawa–Carleton (Figure CP–11–1). The quarry was opened in 1975 by the present owner and operator Thomas Cavanagh Construction Ltd. The property is licensed for an area of 20.23 ha.

The quarry produces crushed aggregate on a single lift of 9.7 m. The disturbed area is about 10 ha.

### GEOLOGY

The 10.4 m deep quarry exposes limestones and dolostones of the lower member of the Gull River Formation. The two rock types alternate in intervals of 2 m to 4 m. A small fault trends across the quarry at 105° with a down–throw to the north of 20 cm. Also present, although apparently not associated with the fault, is a small monoclinal fold which displaces the strata about 2 m down to the south. Glacial overburden around the quarry ranges from 1 to 3 m in thickness.

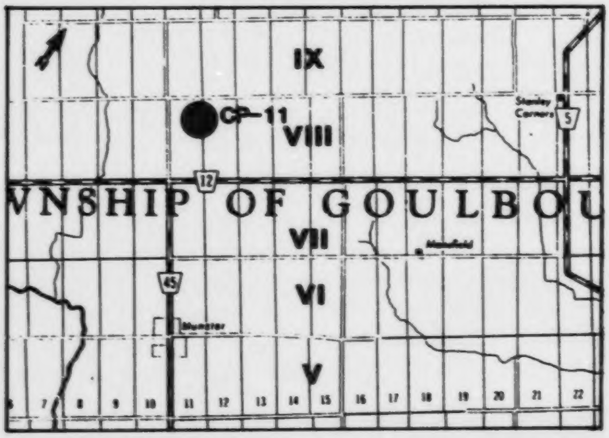


**Figure CP–11–1. LOCATION MAP FOR GOULBOURN QUARRY.**

### Geological Section

*Thickness*

*UNIT 6 Gull River Formation, lower member* *4.2m*

Limestone: medium grey, weathers light grey, microcrystalline to fine crystalline; thin to medium bedded (5–25 cm) with thin interbeds of light grey–green dolostone and dark grey shale.

*UNIT 5 Gull River Formation, lower member* *0.8m*

Dolostone: grey–green to grey–brown, weathers light grey–green to light grey–brown; fine crystalline with varying amounts of very fine–grained terrigenous material; medium bedded (15–25 cm); some beds range from dolomitic limestone to calcitic dolostone.

*UNIT 4 Gull River Formation, lower member* *1.0m*

Dolostone: grey–brown to grey–green, weathers light grey–brown to light grey–green; fine crystalline with varying amounts of very fine–grained terrigenous material; medium bedded (20–25 cm) with thin (1–2 cm), dark grey shale interbeds; some beds of calcitic dolostone are also present; burrows common, especially in and near shale beds.

*UNIT 3 Gull River Formation, lower member* *0.4m*

Dolostone: grey–brown to grey–green, weathers light grey–brown to light grey–green; fine crystalline with varying amounts of very fine–grained terrigenous material; medium bedded (15–25 cm).

*UNIT 2 Gull River Formation, lower member* *3.5m*

Limestone: medium grey, weathers light grey; microcrystalline to fine crystalline; medium bedded (10–20 cm) with thin shale partings between most beds.

*UNIT 1 Gull River Formation, lower member* *0.5m*

Dolostone: grey–green to grey–brown, weathers light grey–green to dark grey–brown; fine crystalline; medium bedded (15–25 cm); some beds of calcitic dolostone are also present.

*Total thickness* *10.4m*

### QUARRY OPERATION

All drilling and blasting is performed by Thomas Cavanagh Construction Ltd. A drill pattern of 2.74 m x 2.74 m is used with 7.6 cm diameter holes. AN/FO is used as a bulk explosive and plastic liners are placed in blast holes in wet conditions.

### PROCESSING

A portable crushing plant is installed at the quarry on a demand basis. Primary crushing is by Cedarapids 36 in. x 45 in. impeller or Cedarapids Commander Crusher. Stone is loaded and hauled to the crusher by a Cat 988B loader.

### PRODUCTS

The Goulbourn Quarry produces various sizes of clear, crusher run and HL stone products.

### REFERENCES

Carson, 1982f, Section C–1
Williams, in prep., Appendix 1 – Section LQ KE–3

### MAPS

Carson, 1982d, OGS Map P.2493

## CP–12 G. TACKABERRY AND SONS CONSTRUCTION CO. LTD. — ROSEDALE QUARRY

### LOCATION AND OWNERSHIP

This quarry located 3.5 km north of the hamlet of Rosedale in Lot 17, Concession 4, Montague Township, Lanark County (Figure CP–12–1), is currently operated by G. Tackaberry and Sons Construction Co. Ltd. The quarry is licensed for an area of 18.37 ha.

### GEOLOGY

The 4.5 m deep quarry exposes fine– to medium–crystalline dolostones and sandy dolostones of the March Formation. Green tinges in the rock are the result of minor amounts of glauconite along the bedding planes. Glacial overburden around the quarry is thin.

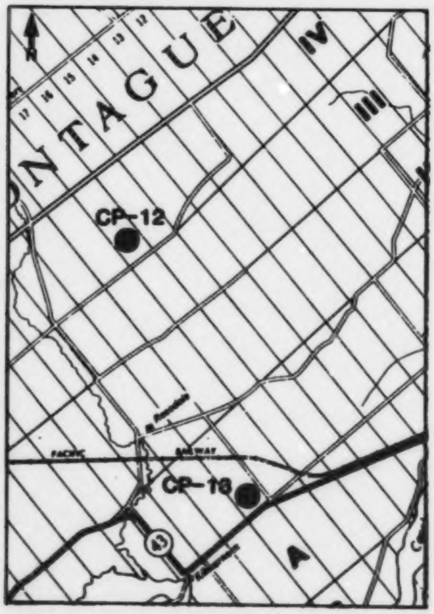


**Figure CP–12–1. LOCATION MAP FOR ROSEDALE QUARRY.**

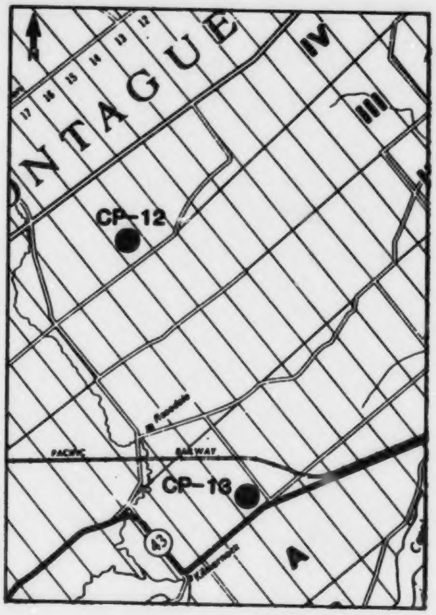


**Figure CP–13–1. LOCATION MAP FOR KILMARNOCK QUARRY.**

### Geological Section

| | *Thickness* |
|---|---|
| *UNIT 1 March Formation* | *4.5m* |
| Dolostone: medium grey–brown to medium grey, weathers light grey–brown with light green tinge along bedding planes; fine to medium crystalline; thin bedded (5–10 cm), with sharp, slightly irregular bedding contacts; most beds contain some amount of well- rounded coarse grains of quartz, some beds contain significant amounts; vugs very abundant throughout unit, most small and completely filled with calcite, larger vugs partially filled with large calcite crystals with rare small pyrite crystals present; green tinge due to glauconite; very large burrows on some bedding planes. | |
| *Total thickness* | *4.5m* |

### REFERENCES

Williams, in prep., Appendix 1 – Section LQ ME–3

### MAPS

Carson, 1982e, OGS Map P.2494

## CP–13 G. TACKABERRY AND SONS CONSTRUCTION CO. LTD. — KILMARNOCK QUARRY

### LOCATION AND OWNERSHIP

This quarry, located on Highway 43, 2 km northeast of Kilmarnock in Lot 19, Concession 1, Montague Township, Lanark County (Figure CP–13–1), has been operated intermittently by G. Tackaberry and Sons Construction Co. Ltd.

### GEOLOGY

The 6.0 m deep quarry exposes fine-crystalline, medium-bedded dolostones of the Oxford Formation. Overburden around the quarry is about 1 m thick.

### Geological Section

*Thickness*

*UNIT 1 Oxford Formation* *6.0m*

Dolostone: light grey-brown weathers light brown; fine crystalline; medium bedded (10-20 cm) with sharp and planar contacts; vugs filled with calcite crystals common in some beds.

*Total thickness* *6.0m*

### REFERENCES

Williams, in prep., Appendix 1 – Section LQ ME-4

### MAPS

Carson, 1982e, OGS Map P.2494

## CP-14 R.W. TOMLINSON LTD. – FALLOWFIELD QUARRY

### LOCATION AND OWNERSHIP

The Fallowfield Quarry is located in Lots 24 and 25, Concession 5, City of Nepean, Regional Municipality of Ottawa-Carleton (Figure CP-14-1), 1.5 km northeast of Fallowfield. Since opening in 1979 the quarry has been owned and operated by R. W. Tomlinson Ltd. The quarry is licensed for 29.6 ha. The extracted area is about 14.2 ha with quarrying of a single lift of 6.1 m to 10.7 m.

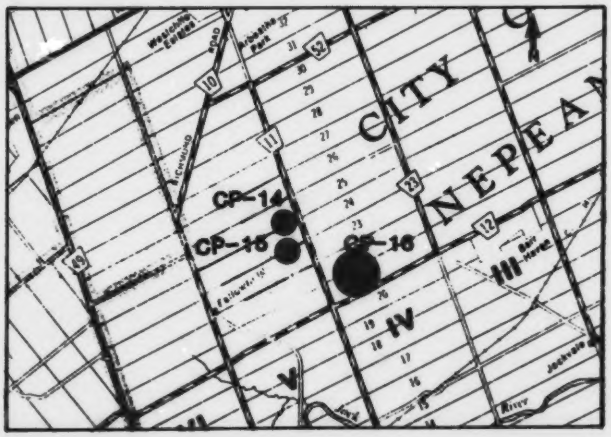


**Figure CP-14-1. LOCATION MAP FOR FALLOWFIELD QUARRY.**

An extensive study of the quarry property has been completed by the operator and establishes a reserve of concrete-quality stone. Core samples recovered to a depth of approximately 30 m have been analyzed for alkali reactivity.

### GEOLOGY

The 10.9 m deep quarry exposes thin-bedded shaly limestones of the upper member of the Gull River Formation and the overlying thick-bedded limestones of the lower member of the Bobcaygeon Formation. A few minor faults were observed in the faces of the quarry, but often could not be traced across the quarry because of large stockpiles of crushed stone against the quarry walls. Overburden around the quarry is generally less than 2 m thick.

### Geological Section

*Thickness*

*UNIT 3 Bobcaygeon Formation, lower member* *3.3m*

Limestone: medium to dark grey, weathers blue-grey to brown; very fine to fine crystalline; medium to thick bedded (25-50 cm) with rare thinner beds, with sharp and planar contacts, and rare, thin, dark grey shale partings; moderately fossiliferous with brachiopods most abundant; lower contact of unit is gradational where shale partings become more abundant.

*UNIT 2 Bobcaygeon Formation, lower member* *2.7m*

Limestone: medium to dark grey-brown, weathers blue-grey to light brown; fine crystalline, with some very fine-crystalline to microcrystalline beds; medium to thickly bedded (25-50 cm) with rare thinner beds, sharp and irregular contacts, with very rare and very thin shale partings; lower contact of unit is sharp at base of thicker bedded, generally shale-free limestone.

*UNIT 1 Bobcaygeon Formation, lower member* *4.9m*

Limestone: light to dark grey, weathers light blue-grey to dark grey; microcrystalline with some fine-crystalline beds; thin to medium bedded (5-15 cm) with rare thicker beds, sharp and planar contacts with shale partings, rarely up to 1 cm thick, common between most beds.

*Total thickness* *10.9m*

### QUARRY OPERATION

A 2.74 m x 2.74 m drill pattern with 8.9 cm diameter holes is used; blast holes are loaded with AN/FO which is initiated with electric caps. A Huff 560 loader (7 yd.) with a Cat 245 shovel are used to load blasted stone into 30-ton Terex haulage trucks.

### PROCESSING

A 48 in. x 66 in. Hewitt-Robins impact crusher feeds a 5 ft. x 14 ft. scalping screen, from which oversize is sent for secondary crushing by two 30 in. x 42 in. Hewitt-Robins hammer mills. Undersize from the scalping screen and secondary crushed material are fed to two 6 ft. x 16 ft. Hewitt-Robins triple-deck screens. A 6,000 lb. batch asphalt plant located on the site is jointly owned by R.W. Tomlinson Ltd. and Tarcon Ltd. Approximately

35% of all asphalt stone produced at the quarry is supplied to the plant.

### PRODUCTS

Granular Stone
Asphalt Stone
5/16 in. stone (for cement block manufacture)
Clear Stone and Concrete Stone

### REFERENCES

Williams, in prep., Appendix 1 - Section LQ OT-4

### MAPS

Williams, Rae and Wolf, 1984, OGS Map P.2716

## CP-15 GEORGE WIMPEY CANADA LTD. — MOODIE DRIVE (FALLOWFIELD) QUARRY

### LOCATION AND OWNERSHIP

The Moodie Drive (Fallowfield) Quarry, is located 1.5 km northeast of Fallowfield in Lot 23 and Lot 24, Concession 5, City of Nepean, Regional Municipality of Ottawa-Carleton (Figure CP-15-1). The quarry was owned and operated by H. J. McFarland Construction Ltd. since 1960 and is now licensed by George Wimpey Canada Ltd. Approximately 36 ha of a licensed area of 82.4 ha have been opened and over 18,000,000 tonnes of aggregate removed from the quarry. Two asphalt batch plants of 12,000 lbs. and 5,000 lbs. operate at the site; the former replaced a 4,000 lb. plant in late 1986.

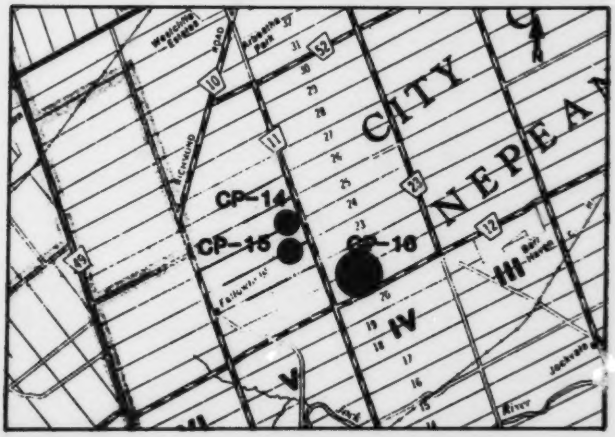


**Figure CP-15-1. LOCATION MAP FOR MOODIE DRIVE (FALLOWFIELD) QUARRY.**

### GEOLOGY

The three lifts in the quarry expose a total of 36.2 m of section, with the deepest part of the quarry at the northeast end. Limestones and dolostones of the lower member of the Gull River Formation are overlain by thin-bedded shaly limestones of the upper member. Thick-bedded limestones of the lower member of the Bobcaygeon Formation at the top of the quarry overlie the Gull River Formation (Figure CP-15-2).

The section is disrupted by several normal faults, in which displacements are generally less than 3 m. In addition, the quarry floor exhibits large buckles (Adams, 1982), although some were subsequently removed when the lower lift was enlarged. Glacial overburden around the quarry ranges from 2 to 3 m in thickness.

### Geological Section

*Thickness*

*UNIT 13 Bobcaygeon Formation, lower member* *5.9m*

Limestone: medium to dark grey-brown, weathers blue-grey to light brown; very fine to fine crystalline; medium to thick bedded (25-50 cm) with some thinner beds present, sharp contacts with very thin shale partings present between a few beds; lower contact of unit is sharp at base of shale-free, thicker-bedded limestone.

*UNIT 12 Gull River Formation, upper member* *9.2m*

Limestone, with shale partings: dark grey, weathers dark grey, except for a white, 25 cm thick bed 7.0 m above base of unit; microcrystalline to fine crystalline; thin to medium bedded (5-20 cm), with rare thicker beds, sharp and planar to undulating contacts with shale partings up to 1 cm thick common between most beds; intraclasts of light grey, microcrystalline limestone occur in some beds of fine-crystalline limestone; small patches of calcite crystals, "birdseye" texture, commonly occur throughout unit; moderately fossiliferous, colonial coral *Tetradium* most common; lower contact of unit is sharp.

*UNIT 11 Gull River Formation, lower member* *0.7m*

Dolostone: medium grey, weathers light brown to buff; very fine to fine crystalline with a minor amount of terrigenous mud and silt; thin to medium bedded (5-15 cm), with thin shale partings between some beds; lower contact of unit is sharp.

*UNIT 10 Gull River Formation, lower member* *3.2m*

Limestone: dark grey, weathers light to medium grey, commonly with a blue-grey tinge; microcrystalline to fine crystalline; thin to thick bedded (5-50 cm) with thin shale partings between some beds; lower contact of unit is sharp.

*UNIT 9 Gull River Formation, lower member* *0.6m*

Limestone: dark grey, weathers medium grey with blue-grey tinge; medium bedded (30 cm) with thin shale partings; oolites and light to medium grey, microcrystalline intraclasts abundant throughout unit; lower contact of unit is sharp.

*UNIT 8 Gull River Formation, lower member* *1.1m*

Dolostone: green-grey, weathers buff to red-brown; very fine crystalline; thin to medium bedded (5-20 cm) with thin shale partings common; intraclasts of light brown, fine-crystalline dolostone present; some parts of unit are slightly calcitic; lower contact of unit is sharp.

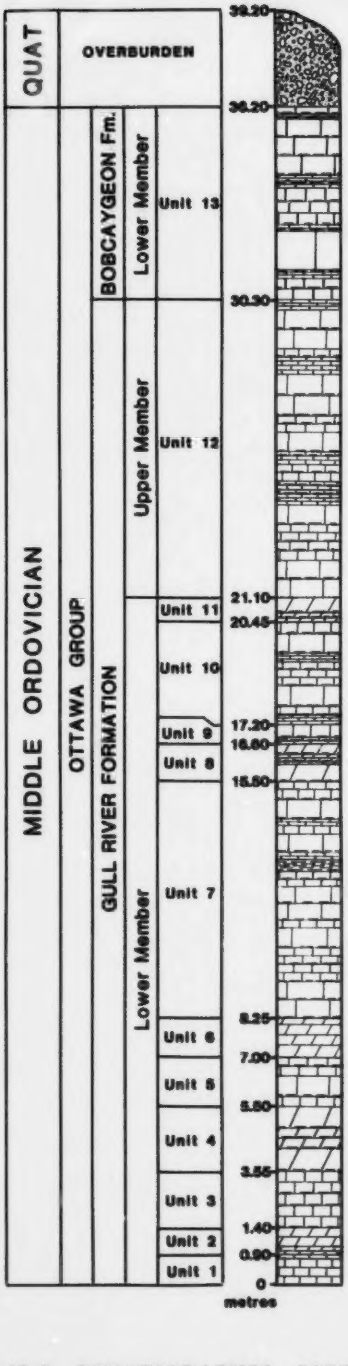


**Figure CP-15-2. STRATIGRAPHIC COLUMN FOR MOODIE DRIVE (FALLOWFIELD) QUARRY.**

| | |
|---|---|
| *UNIT 7 Gull River Formation, lower member* | *7.3m* |

Limestone: dark grey, weathers blue-grey; microcrystalline to fine crystalline; thin to thick bedded (5-50 cm) with thin shale partings common between most beds; intraclasts of light grey microcrystalline limestone common in some beds; moderately fossiliferous with brachiopods most abundant; black shale bed, 20 cm thick, 4.7-4.9 m above base of unit; lower contact of unit is sharp.

| | |
|---|---|
| *UNIT 6 Gull River Formation, lower member* | *1.2m* |

Dolostone: medium grey, weathers light green-grey to light brown; very fine to fine crystalline with minor amount of terrigenous mud and silt; medium bedded (20 cm); vugs filled with calcite crystals present in most beds; lower contact of unit is sharp.

| | |
|---|---|
| *UNIT 5 Gull River Formation, lower member* | *1.5m* |

Limestone: dark grey, weathers same; microcrystalline, with some fine crystalline beds; medium to thick bedded (20-50 cm); lower contact of unit is sharp.

| | |
|---|---|
| *UNIT 4 Gull River Formation, lower member* | *2.0m* |

Dolostone: light grey-green, weathers buff to light brown; very fine to fine crystalline; medium to thick bedded (20-60 cm) with thin shale partings present between some beds; vugs filled with calcite crystals common in some beds; lower contact of unit is sharp.

| | |
|---|---|
| *UNIT 3 Gull River Formation, lower member* | *2.1m* |

Limestone: dark grey, weathers same with blue-grey tinge; microcrystalline to very fine crystalline; medium bedded (20-30 cm) with thin shale partings between some beds; lower contact of unit is sharp.

| | |
|---|---|
| *UNIT 2 Gull River Formation, lower member* | *0.5m* |

Dolostone: medium grey, weathers grey-green; very fine crystalline with minor amounts of terrigenous mud and silt; thin to medium bedded (5-15 cm); lower contact of unit is sharp.

| | |
|---|---|
| *UNIT 1 Gull River Formation, lower member* | *0.9m* |

Limestone: dark grey, weathers same with blue-grey tinge; fine crystalline; medium bedded (20-30 cm).

| | |
|---|---|
| *Total thickness* | *36.2m* |

## QUARRY OPERATION

The surface elevation of bedrock rises progressively to the west. Three lifts have been excavated to date at heights of 7.6 m to 15.2 m, 10.7 m to 15.2 m, and 10.7 m to 15.2 m. The third (lower) lift is normally operated during the dry summer months, but was flooded throughout 1986.

A drill pattern of 3 m x 3 m is used with 7.6 cm diameter holes. Holes are loaded with Powerfrac and AN/FO which is initiated with electric delay caps.

A Cat 988B loader (7 yd.) is used to load three 35-ton Terex trucks. A fourth truck (Wabco) is added for long haulage distances of 600 m to 900 m to keep pace with the crushing capacities.

## PROCESSING

The process flow sheet is shown on Figure CP-15-3. A 30 in. x 42 in. Lipman (Grizzly King) jaw crusher feeds a 40 in. x 72 in. scalping screen producing 2 in. crusher

Photo CP-15-1.
VIEW OF MOODIE DRIVE (FALLOWFIELD) QUARRY (LOOKING WEST).

Photo CP-15-2.
NEW 12,000 LB. ASPHALT BATCH PLANT AT THE MOODIE DRIVE (FALLOWFIELD) QUARRY (LOOKING NORTHWEST).

run (stockpile) and −12 in. + 2 in. oversize that passes to a 36 in. x 45 in. Cedarapids double impeller crusher. Stone leaving the secondary crusher is conveyed to two Cedarapids 4 ft. x 14 ft. triple-deck screens (two decks are used), providing −6 in. +2 in. material to a Symons 4 1/4 ft. standard cone crusher, −2 in. + 1 1/4 in. material to a Symons 4 1/4 ft. short head crusher and a −1 1/4 in. fines product to a second pair of Cedarapids 4 ft. x 14 ft. triple-deck screens. Stone leaving the two Symons crushers is sent back in closed circuit to the first pair of 4 ft. x 14 ft. screens. The second set of Cedarapids 4 ft. x 14 ft. screens produce screenings, HL4 and 3/4 in. clear to three 50-ton bins, and a −1 1/4 in. + 7/8 in. oversize to a Hazemag APS-1013K hammer mill. Stone leaving the hammer mill passes over a 5 ft. x 16 ft. Cedarapids triple-deck screen, producing 3/4 in. clear (bedding stone), HL4 and screenings.

Adjustments to the screen processes, and blending of sizes, allow the production of a wide variety of grades of stone.

## PRODUCTS

Armour Stone
Riprap
Gabion Stone
Blasted Rock
6 in. Crusher Run
4 in. Crusher Run
2 in. Crusher Run
Granular "A"
2 in. Clear
1 in. Clear
3/4 in. Clear
5/8 in. Clear

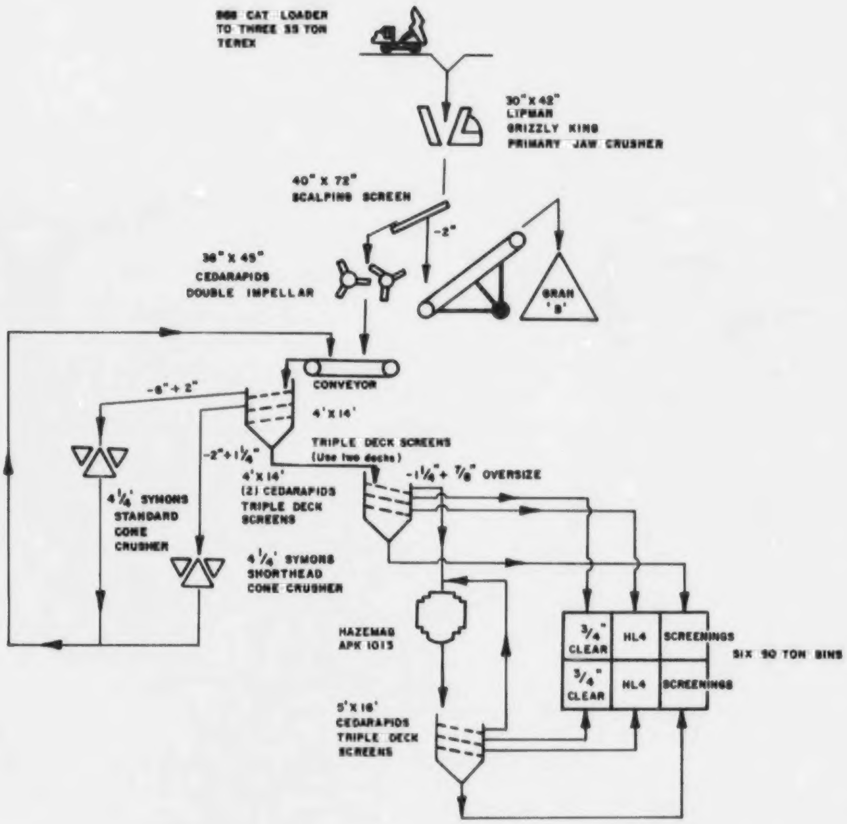

988 CAT LOADER
TO THREE 35 TON
TEREX
30"X42"
LIPMAN
GRIZZLY KING
PRIMARY JAW CRUSHER
40" X 72"
SCALPING SCREEN
-2"
36" X 45"
CEDARAPIDS
DOUBLE IMPELLAR
GRAN
'B'
CONVEYOR
-6"+2"
4'X14'
TRIPLE DECK SCREENS
(Use two decks)
-2"+1¼"
4'X14'
(2) CEDARAPIDS
TRIPLE DECK
SCREENS
-1¼"+ ⅞" OVERSIZE
4¼' SYMONS
STANDARD
CONE
CRUSHER
4¼' SYMONS
SHORTHEAD
CONE CRUSHER
HAZEMAG
APK 1013
¾"
CLEAR
HL4
SCREENINGS
SIX 50 TON BINS
5'X16'
CEDARAPIDS
TRIPLE DECK
SCREENS

Figure CP-15-3. PROCESS FLOW SHEET FOR MOODIE DRIVE (FALLOWFIELD) QUARRY.

3/4 in. Concrete Stone
5/8 in. Concrete Stone
3/8 in. chips/concrete stone
5/16 in. chips/concrete stone
1/4 in. chips
HL4/5 Stone
HL6/8 Stone
Screenings
HL1 Mix
HL2 Mix
HL3 Mix
HL4 Mix
HL5 Mix
HL6 Mix
HL3 Fine Mix
HL8 Mix
Open Friction Course Stone
Dense Friction Course Stone
Rubber Granule
Rubber Latex
HL3 Modified Mix
HL4/5 Modified Mix
HL6/8 Modified Mix
Cold Patch
Driveway Mix

### REFERENCES

Hewitt, 1964a, p.38
Hewitt and Vos, 1972, p.30–31
Adams, 1982
Williams, in prep., Appendix 1 – Section LQ OT-3

### MAPS

Williams, Rae and Wolf 1984, OGS Map P.2716

## CP-16 WARREN PAVING & MATERIALS GROUP LTD. — HOULAHAN (FALLOWFIELD) QUARRY

### LOCATION AND OWNERSHIP

This large quarry, located 2.5 km east of Fallowfield in Lot 21, Concession 4, City of Nepean. Regional Municipality of Ottawa–Carleton (Figure CP-16–1), is operated on a demand basis by Dibblee Construction Company Limited, a subsidiary of Warren Paving & Materials Group Ltd.. The quarry licence covers an area of 26.3 ha. After about four years of inactivity, the quarry was projected to reopen in early 1987 with portable equipment.

## GEOLOGY

This quarry exposes at least 18.7 m of the lower and upper members of the Gull River Formation, and part of the lower member, Bobcaygeon Formation in two lifts. The lower lift is partially filled with water so that the total quarry depth is not known and the detailed description (below) begins at the 1986 water level. The interbedded dolostones and limestones of the lower member, Gull River Formation are overlain by the thin-bedded, shaly limestone of the upper member. The quarry is capped by the thick-bedded, microcrystalline limestones of the lower member, Bobcaygeon Formation. Recent excavation of the northeast corner has revealed a zone of spectacular folding. Glacial overburden around the quarry is 1 to 2 m thick.

### Geological Section

*Thickness*

*UNIT 7 Bobcaygeon Formation, lower member* *1.5m*

Limestone: medium to dark grey-brown, weathers brown to grey-brown with blue-grey tinge; microcrystalline to fine crystalline; generally a single bed which weathers out into 25-50 cm thick partings; lower contact of unit sharp and slightly irregular.

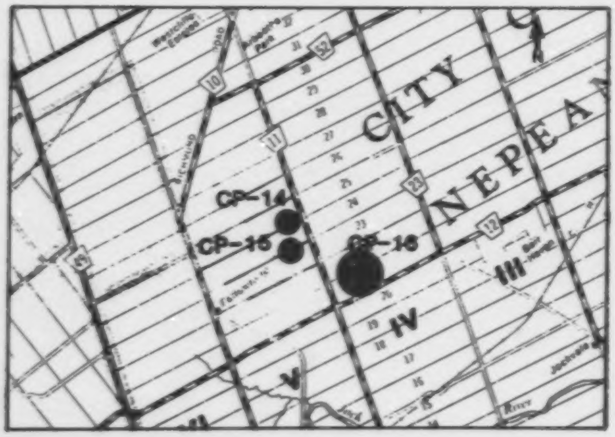


**Figure CP-16-1. LOCATION MAP FOR HOULAHAN (FALLOWFIELD) QUARRY.**

*UNIT 6 Gull River Formation, upper member* *7.1m*

Limestone with shale partings: dark grey, weathers light blue-grey to dark grey, with a white bed between 4.8-5.1 m above base of unit; microcrystalline to fine crystalline; thin to medium bedded (5-15 cm) with rare thicker beds, bedding contacts sharp with shale partings up to 1 cm thick common between beds; small patches of calcite crystals, "birdseye" texture, common in some beds; intraclasts of light grey, microcrystalline limestone common in some fine-crystalline beds; moderately fossiliferous, with brachiopods and the colonial coral *Tetradium* most common; lower contact of unit sharp and planar.

*UNIT 5 Gull River Formation, lower member* *0.6m*

Dolostone: medium grey, weathers buff; fine crystalline; thin to medium bedded (5-20 cm), with sharp and planar contacts; lower contact of unit sharp and planar.

*UNIT 4 Gull River Formation, lower member* *5.3m*

Limestone: dark grey, weathers blue-grey; microcrystalline to very fine crystalline; medium to thick bedded (10-50 cm), with thin shale partings present between some beds; lower contact of unit sharp and planar.

*UNIT 3 Gull River Formation, lower member* *0.6m*

Limestone: dark grey, weathers medium grey; oolitic with numerous microcrystalline limestone intraclasts in a very fine-crystalline matrix; medium bedded (20-30 cm), with thin, shale partings present between some beds; lower contact of unit sharp and irregular; top of lower lift at top of unit.

*UNIT 2 Gull River Formation, upper member* *1.1m*

Dolostone: grey-green, weathers grey-brown to reddish brown; very fine to fine crystalline, with significant amounts of very fine- grained quartz sand and silt; thin to medium bedded (5-15 cm), with shale partings common between beds; some intervals slightly calcitic; scattered intraclasts of light brown, silty dolostone in some intervals; lower contact of unit sharp and planar.

*UNIT 1 Gull River Formation, lower member* *2.5m*

Limestone: dark grey, weathers blue-grey; microcrystalline to very fine crystalline; medium to thick bedded (10-50 cm), with thin, dark grey shale partings common; scattered intraclasts of light grey, microcrystalline limestone in some intervals; moderately fossiliferous, with brachiopods most abundant; (lower contact of unit is at water level).

*Total thickness* *18.7m*

## REFERENCES

Hewitt, 1964a, p.39
Williams and Telford, 1986, p.14-16
Williams, in prep., Appendix 1 - Section LQ OT-5.

## MAPS

Williams, Rae and Wolf, 1984, OGS Map P.2716

# CP-17 UNITED AGGREGATES LTD. — SOUTH GLOUCESTER QUARRY

## LOCATION AND OWNERSHIP

This large quarry, located 3 km north of the hamlet of South Gloucester, in Lots 23-25, Concession 5, City of Gloucester, Regional Municipality of Ottawa-Carleton

(Figure CP-17-1), is operated by Armbro Aggregates, a division of United Aggregates Limited since 1984. The quarry is licensed for 122.21 ha, and the excavated area of the quarry is approximately 37 ha.

## GEOLOGY

The 27.3 m deep quarry exposes strata of the March and Oxford Formations (Figure CP-17-2). Interbedded sandstones, sandy dolostones, and dolostones of the March Formation occur in the lower 15 m at the eastern end of the quarry. Dolostones of the overlying Oxford Formation occur at the top of the quarry; at the eastern end a total of 12 m is exposed. As the strata have a shallow westerly dip an additional 6 m of section is present at the western end of the quarry. The following description is of a section located at the eastern end of the quarry. Glacial overburden around the quarry varies from 1 to 3 m in thickness.

### Geological Section

| | *Thickness* |
|---|---|
| *UNIT 11 Oxford Formation* | *12.1m* |

Dolostone: grey-brown, weathers grey-brown to buff; fine to medium crystalline; medium to thick (10-50 cm) bedded, with thin, grey-brown shale partings present between a few beds; some intervals slightly calcitic; calcite-filled vugs common in some beds, scattered throughout most beds; lower contact of unit sharp and slightly irregular.

| | |
|---|---|
| *UNIT 10 March Formation* | *0.4m* |

Sandy dolostone: grey-brown, weathers medium grey; fine-crystalline dolostone with medium- to coarse-grained quartz sand; slightly calcitic; single bed; calcite-filled vugs common; lower contact of unit sharp and planar.

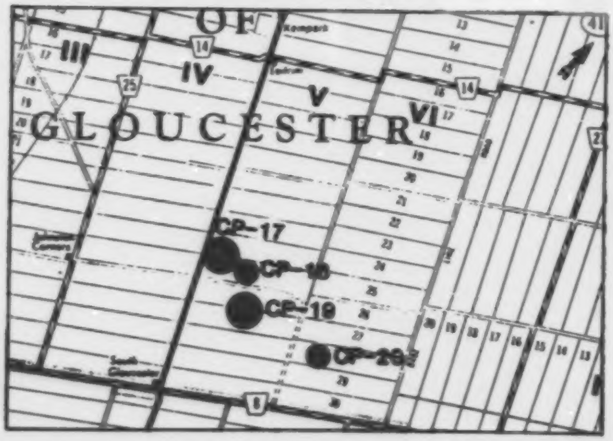

OF
III
IV
V
VI
GLOUCESTER
14
25
41
8
CP-17
CP-18
CP-19
CP-20

Figure CP-17-1. LOCATION MAP FOR SOUTH GLOUCESTER QUARRY.

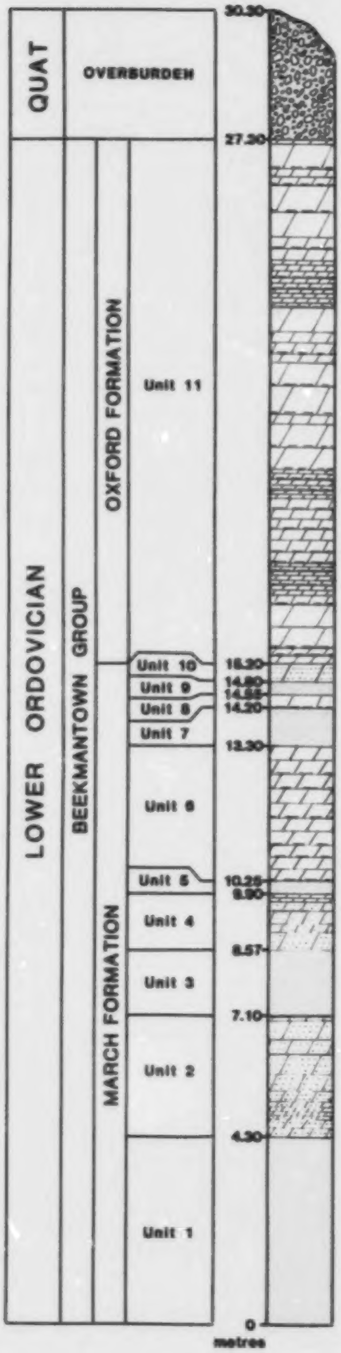

QUAT
OVERBURDEN
LOWER ORDOVICIAN
BEEKMANTOWN GROUP
OXFORD FORMATION
MARCH FORMATION
Unit 11
Unit 10
Unit 9
Unit 8
Unit 7
Unit 6
Unit 5
Unit 4
Unit 3
Unit 2
Unit 1
30.30
27.30
15.20
14.80
14.55
14.20
13.30
10.25
9.90
8.57
7.10
4.30
0
metres

Figure CP-17-2. STRATIGRAPHIC COLUMN FOR SOUTH GLOUCESTER QUARRY.

*UNIT 9 March Formation* *0.3m*

**Sandstone: white to light grey, weathers same; fine to medium grained with a calcitic cement; single bed; lower contact of unit sharp and planar.**

*UNIT 8 March Formation* *0.3m*

**Dolostone: grey-brown, weathers grey-green to buff; fine to medium crystalline; slightly calcitic; single bed with shale partings at top and bottom; calcite-filled vugs present; lower contact of unit sharp.**

*UNIT 7 March Formation* *0.9m*

**Sandstone: white to light grey, weathers white to reddish brown; fine to medium grained, with slightly calcitic cement; single bed; lower contact of unit sharp and slightly irregular.**

*UNIT 6 March Formation* *3.1m*

**Dolostone: grey-brown, weathers grey-green to buff; fine to medium crystalline; slightly calcitic in some intervals; medium (10-30 cm) bedded, with thin, dark grey shale partings present between some beds; calcite-filled vugs scattered throughout most beds; lower contact of unit sharp and planar.**

*UNIT 5 March Formation* *0.3m*

**Sandstone: white to light grey, weathers white to reddish brown; fine to medium grained, with slightly calcitic cemeht; single bed; lower contact of unit sharp and slightly irregular.**

*UNIT 4 March Formation* *1.3m*

**Sandy dolostone: light grey to grey-brown, weathers medium grey to grey-green; very fine- to fine-crystalline dolostone with medium- to coarse-grained quartz sand; medium bedded; calcite-filled vugs common; lower contact of unit sharp and planar.**

*UNIT 3 March Formation* *1.5m*

**Sandstone: white to light grey, weathers white to reddish brown; fine to medium grained, with a dolomitic and quartz cement; thin to medium bedded; lower contact of unit sharp and planar.**

*UNIT 2 March Formation* *2.8m*

**Sandy dolostone: grey-brown, weathers medium grey; fine crystalline with medium to coarse-grained quartz sand; medium to thick (10-50 cm) bedded; calcite-filled vugs common; lower contact of unit sharp and planar.**

*UNIT 1 March Formation* *4.3m*

**Sandstone: white to light grey, weathers white to reddish brown; fine to medium grained; thin to massive bedded, with thin calcareous shale partings between some beds; small-scale crossbeds present in most beds.**

*Total thickness* *27.3m*

## QUARRY OPERATIONS

The quarry is worked on three lifts of 12 m, 8 m and 7 m. A drill pattern of 2.74 m x 2.74 m with 10.2 cm diameter blast holes is used on the top and middle lifts. The bottom lift is a very hard dolomitic sandstone and requires a drilling pattern of 2.43 m x 2.43 m with 10.2 cm blast holes to achieve good blast fragmentation. The bottom lift was opened in 1981 and is excavated solely to produce HL3 modified stone, a top quality skid-resistant aggregate used for asphalt surfaces on high traffic volume highways. The South Gloucester Quarry is one of a limited number of quarries currently producing HL3 modified. A Cat 988B loader is used to load Cat 769B 35-ton haulage trucks. Two trucks are used for haulage from the top and middle lifts, averaging a distance of about 330 m and a third truck is required for haulage from the bottom lift, a distance of approximately 500 m to the crusher.

## PROCESSING

The blasted stone is crushed by a 42 in. x 48 in. Pioneer jaw crusher, feeding a Simplicity screen. Oversize from the screen (+4 in.) is re-crushed by a Symons 5 1/2 ft. cone and undersize is stockpiled in a -4 in. surge pile. The re-crushed material from the Symons cone is added to the surge pile. Stone recovered from the surge pile is re-crushed by two Symons 5 1/2 ft. cones, feeding three 8 ft. x 20 ft. Tyler triple-deck screens. The South Gloucester Quarry supplies concrete stone for local ready-mix plants, asphalt stone and 1 in. weeping bed stone.

## PRODUCTS

Granulars
1 in. Clear (weeping bed stone)
3/4 in. Clear
3/4 in. Concrete Stone
HL3 modified
HL3

## REFERENCES

Hewitt, 1960, p.24
Hewitt, 1964a, p.26

**Photo CP-17-1. WEST QUARRY FACE AT THE SOUTH GLOUCESTER QUARRY.**

Hewitt and Vos, 1972, p.7
Rogers, 1980, p.40–44
Williams and Telford, 1986, p.16
Williams, in prep., Appendix 1 – Section LQ OT–7

### MAPS

Williams, Rae and Wolf, 1984, OGS Map P.2716

## CP–18 WARREN PAVING & MATERIALS GROUP LTD. — BOYCE (SOUTH GLOUCESTER) QUARRY

### LOCATION AND OWNERSHIP

The Boyce Quarry is located in the south half of Lot 25, Concession 5, City of Gloucester, Regional Municipality of Ottawa–Carleton (Figure CP–18–1), immediately southeast of the South Gloucester Quarry (CP–17). The quarry produces aggregates solely for company use in construction projects. The Boyce Quarry was opened in 1964 by Dibblee Construction Company, now part of Warren Paving & Materials Group Ltd. The quarry licence covers an area of 50.58 ha.

### GEOLOGY

The 15.2 m deep quarry exposes sandstones, sandy dolostones, and dolostones of the March Formation, which are overlain by the dolostones of the Oxford Formation. The section exposed is similar to that in the adjacent quarry of United Aggregates (CP–17). Glacial overburden around the quarry is 1 to 3 m thick.

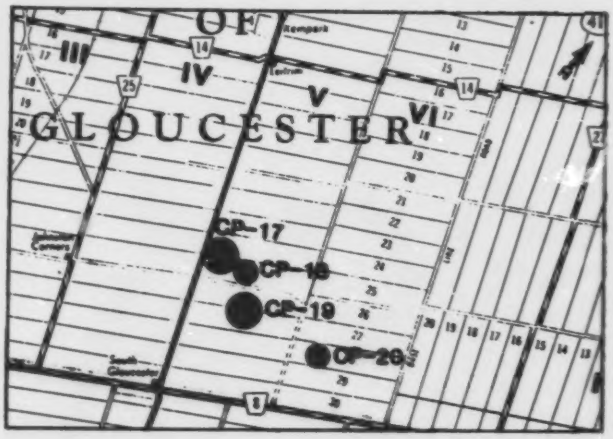


**Figure CP-18-1. LOCATION MAP FOR BOYCE (SOUTH GLOUCESTER) QUARRY.**

### Geological Section

*Thickness*

*UNIT 11 Oxford Formation* *1.1m*

Dolostone: medium grey, weathers buff; fine crystalline; thin bedded; lower contact of unit sharp and planar.

*UNIT 10 Oxford Formation* *0.8m*

Dolostone: light grey, weathers same; fine crystalline; thin bedded; intraclasts of grey-brown silty dolostone in some beds; lower contact of unit sharp and planar.

*UNIT 9 Oxford Formation* *0.4m*

Dolostone: medium grey, weathers same, fine crystalline; single bed; lower contact of unit sharp and planar.

*UNIT 8 Oxford Formation* *0.6m*

Dolostone: light grey, weathers same; very fine crystalline; thin to medium bedded, with thin shale partings; lower contact of unit sharp and planar.

*UNIT 7 Oxford Formation* *1.7m*

Dolostone: medium grey, weathers light to medium grey; fine crystalline; medium bedded; calcite-filled vugs present in some beds; lower contact of unit sharp and planar.

*UNIT 6 Oxford Formation* *3.0m*

Dolostone: light to medium grey, weathers medium grey; fine crystalline; thin bedded with thin shale partings between some beds; calcite-filled vugs present in some beds; lower contact of unit sharp and slightly irregular.

*UNIT 5 March Formation* *0.4m*

Sandy dolostone: grey-brown, weathers medium grey; fine crystalline with medium- to coarse-grained quartz sand, slightly calcitic in places; single bed; calcite-filled vugs present; lower contact of unit sharp and planar.

*UNIT 4 March Formation* *0.3m*

Sandstone: white to light grey, weathers white to reddish brown; fine to medium grained; single bed, with small-scale crossbeds; lower contact of unit sharp and slightly irregular.

*UNIT 3 March Formation* *0.3m*

Dolostone: grey-brown, weathers buff to grey-green; fine to medium crystalline; single bed, with shale partings at base and top of bed; calcite-filled vugs present; lower contact of unit sharp and planar.

*UNIT 2 March Formation* *0.9m*

Sandstone: white to light grey, weathers white to reddish brown, fine to medium grained; medium bedded, with small-scale crossbeds; lower contact of unit sharp and irregular.

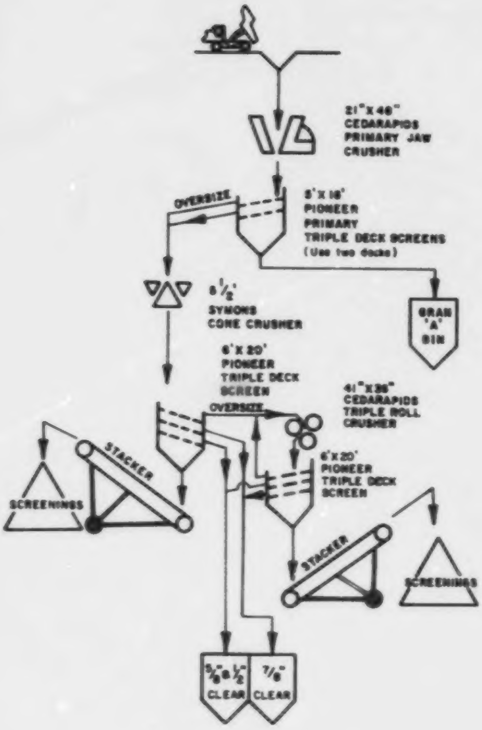
*UNIT 1 March Formation* *5.7m*

Dolostone: grey-brown, weathers buff to grey-green; fine to medium crystalline, with thin intervals containing medium- to coarse-grained quartz sand; medium bedded, with thin, dark grey shale partings between some beds; calcite-filled vugs common in some beds.

*Total thickness* *15.2m*

### QUARRY OPERATION

The property has an excavated area of about 25 ha and is worked on two lifts of 7.6 m. A third lift consisting of hard dolomitic sandstone is available to produce HL3 modified if desired.



21"x48" CEDARAPIDS PRIMARY JAW CRUSHER
5'x16' PIONEER PRIMARY TRIPLE DECK SCREENS (Use two decks)
OVERSIZE
5 1/2' SYMONS CONE CRUSHER
GRAN 'A' BIN
6'x20' PIONEER TRIPLE DECK SCREEN
OVERSIZE
41"x36" CEDARAPIDS TRIPLE ROLL CRUSHER
6'x20' PIONEER TRIPLE DECK SCREEN
STACKER
SCREENINGS
STACKER
SCREENINGS
5/8" & 1/2" CLEAR
7/8" CLEAR

Figure CP-18-2. PROCESS FLOW SHEET FOR BOYCE (SOUTH GLOUCESTER) QUARRY.

All drilling and blasting is subcontracted; a 2.1 m x 2.1 m drill pattern and 7.6 cm diameter holes are used. Holes are often wet, and stick powder (Powerfrac 75% and Cilgel 70%) is used at the toe of the hole. AN/FO is used in blast holes above the water level. Holes are delayed from 0 to 18 milliseconds with electric caps, and blasts are monitored for vibration.

### PROCESSING

The process flow sheet is shown on Figure CP-18-2. Blasted stone is hauled by two Cat 988B and one Yale 7500 (7.25 yd.) loaders to the primary crusher, a Cedarapids 21 in. x 48 in. jaw feeding a Pioneer 5 ft. x 16 ft. triple-deck screen (only two decks are used). The screen produces -7/8 in. Granular "A" that is sent to a storage bin and +7/8 in. oversize that is fed to a Symons 5.5 ft. cone crusher. After this secondary crushing, the stone is sent to a Pioneer 6 ft. x 20 ft. triple-deck screen which produces 7/8 in. clear, 5/8 in. and 1/2 in. clear to bin storage, screenings to a stockpile and oversize to a Cedarapids 41 in. x 36 in. triple roll crusher. Stone leaving the roll crusher feeds a second Pioneer 6 ft. x 20 ft. triple-deck screen which produces 7/8 in. clear, 5/8 in. and 1/2 in. clear, crusher run for bin storage and dust/screenings which are stockpiled.

The crushed stone products are hauled by four 18-ton Hustler trucks to the on-site asphalt plant.

### PRODUCTS

Granular "A" and "B"
HL8 (7/8 in. Clear)
HL4 (5/8 in. Clear)
HL3 (1/2 in. Clear)
Dust

### REFERENCES

Hewitt, 1964a, p.27
Hewitt and Vos, 1972, p.10-11
Rogers, 1980, p.45-48
Williams, in prep., Appendix 1 - Section LQ OT-8

### MAPS

Williams, Rae and Wolf, 1984, OGS Map P.2716

## CP-19 BEAVER ASPHALT PAVING CO. LTD. — OTTAWA (SOUTH GLOUCESTER) QUARRY

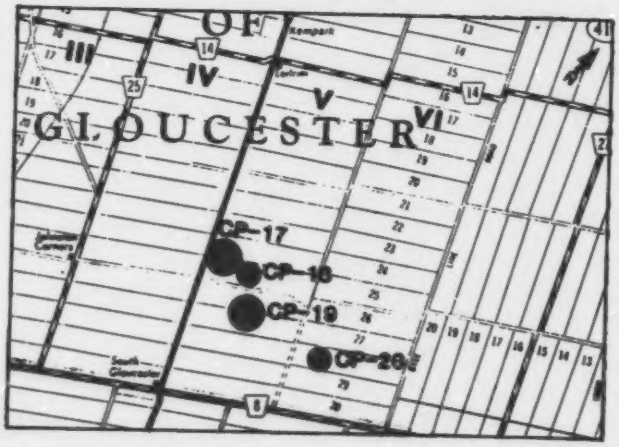
### LOCATION AND OWNERSHIP

The Beaver Asphalt Quarry operation is located approximately 9 km southeast of Ottawa and consists of three properties in the City of Gloucester, Regional Municipality of Ottawa-Carleton (Figure CP-19-1).

The properties are:

(1) The Grant Quarry (formerly operated by Bertrand & Freres Construction), north half of Lot 28, Concession 5, licensed for 35.49 ha.

(2) The Miller Quarry (owned by Michael Miller and Sons), operated by Beaver Asphalt, south half of Lot 27, Concession 5, licensed for 24.28 ha.



OF
GLOUCESTER
III
IV
V
VI
Kempark
14
25
14
41
27
8
South Gloucester
CP-17
CP-18
CP-19
CP-20

Figure CP-19-1. LOCATION MAP FOR OTTAWA (SOUTH GLOUCESTER) QUARRY.

(3) Beaver property, parts of Lot 26 and 27, Concession 5, licensed for 6.07 ha.

The Grant and Miller Quarries are now worked as a single operation and known as the Ottawa Quarry. The third property has not yet been opened for extraction.

Beaver Asphalt Paving Company Ltd. was founded in 1954 and operates mainly in eastern Ontario from headquarters in Ottawa.

## GEOLOGY

The 13.5 m deep quarry exposes fine-crystalline, thin- to medium-bedded dolostones of the Oxford Formation. Calcite-filled vugs are common in many of the beds. Glacial overburden around the quarry varies from 1 to 3 m in thickness.

### Geological Section

| | | *Thickness* |
|---|---|---|
| *UNIT 7* | *Oxford Formation* | *1.5m* |

Dolostone: light grey, weathers buff; very fine crystalline; thin to medium bedded, with thin, dark grey shale partings common; lower contact of unit sharp and planar.

| | | |
|---|---|---|
| *UNIT 6* | *Oxford Formation* | *0.9m* |

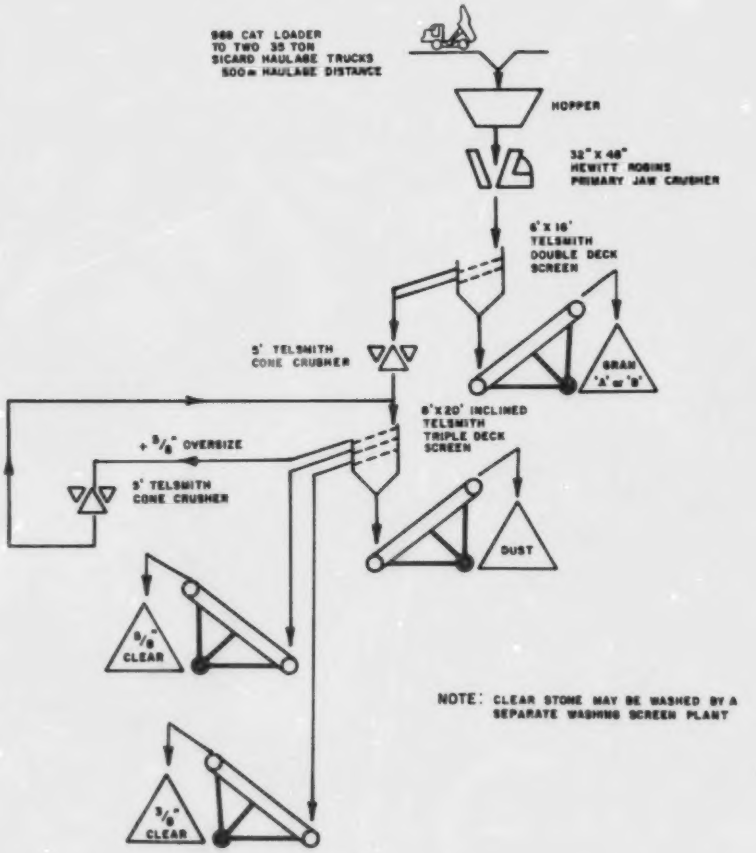
Dolostone: light grey, weathers light grey-green; very fine crystalline; thin bedded; lower contact of unit sharp and planar.

| | | |
|---|---|---|
| *UNIT 5* | *Oxford Formation* | *1.1m* |

Dolostone: medium grey, weathers medium to dark grey; fine crystalline; medium bedded, with thin, dark grey shale partings; calcite-filled vugs common; lower contact of unit sharp and planar.

| | | |
|---|---|---|
| *UNIT 4* | *Oxford Formation* | *0.9m* |

Dolostone: light grey, weathers same; fine crystalline; thin bedded; calcite-filled vugs common; lower contact of unit sharp and planar.


988 CAT LOADER
TO TWO 35 TON
SICARD HAULAGE TRUCKS
500m HAULAGE DISTANCE
HOPPER
32" X 48"
HEWITT ROBINS
PRIMARY JAW CRUSHER
6' X 16'
TELSMITH
DOUBLE DECK
SCREEN
5' TELSMITH
CONE CRUSHER
GRAN
'A' or 'B'
6' X 20' INCLINED
TELSMITH
TRIPLE DECK
SCREEN
+ 5/8" OVERSIZE
5' TELSMITH
CONE CRUSHER
DUST
5/8"
CLEAR
3/8"
CLEAR

NOTE: CLEAR STONE MAY BE WASHED BY A SEPARATE WASHING SCREEN PLANT

Figure CP-19-2. PROCESS FLOW SHEET FOR OTTAWA (SOUTH GLOUCESTER) QUARRY.

*UNIT 3 Oxford Formation* *1.4m*

Dolostone: dark grey, weathers dark grey to dark brown; fine crystalline, medium bedded; calcite-filled vugs common; lower contact of unit sharp and planar.

*UNIT 2 Oxford Formation* *0.8m*

Dolostone: light grey, weathers medium grey; fine crystalline; medium bedded, with thin, dark grey shale partings between some beds, other contacts stylolitic; calcite-filled vugs common; lower contact of unit sharp and planar; top of lower lift at top of unit.

*UNIT 1 Oxford Formation* *6.9m*

Dolostone: medium grey, weathers dark grey; fine crystalline; medium to thick bedded, with thin shale partings rare between some beds; calcite-filled vugs common in most beds.

*Total thickness* *13.5m*

## QUARRY OPERATION

Approximately 80% of the crushed aggregate produced at the Beaver Asphalt Quarry is consumed in company-related construction projects, the balance going to retail sales.

Drilling and blasting is subcontracted and a 2.4 m x 2.7 m drill pattern is used with 7.6 cm diameter holes. The quarry is excavated on a single lift of about 13.5 m, originally two lifts of 4.6 m and 6.1 m in the old Miller Quarry. A Cat 988 loader is used in the quarry to load two 35-ton Sicard trucks that haul approximately 450 m to the primary feed hopper.

## PROCESSING

The flow chart for the processing plant is shown on Figure CP-19-2. The blasted stone is fed to a 32 in. x 48 in. Hewitt-Robins jaw crusher and then to a double-deck 6 ft. x 16 ft. Telsmith screen that produces Granular "A" or "B", and an oversize that is sent to a 5 ft. Telsmith cone crusher. After secondary crushing, the stone is fed to an 8 ft. x 20 ft. triple-deck Telsmith screen that produces dust, 3/8 in. and 5/8 in. chips, and a +5/8 in. oversize that is sent for tertiary crushing by a second 5 ft. Telsmith cone crusher. A separate washing screen is available to make washed aggregate products used for precast concrete.

## PRODUCTS

Beaver Asphalt Paving Co. Ltd. produces a variety of products at this quarry including, but not restricted to, the following:

Granular "A" and "B"
5/8 in. Clear
3/8 in. Clear
Variety of Asphalt Mixes
Dust

## REFERENCES

Hewitt and Vos, 1972, p.8-9

Rogers, 1980, p. 51-52

Williams, in prep., Appendix 1 - Section LQ OT-9

## MAPS

Williams, Rae and Wolf, 1984, OGS Map P.2716

**Photo CP-19-1. HEWITT-ROBINS PRIMARY JAW CRUSHER AT THE OTTAWA (SOUTH GLOUCESTER) QUARRY.**

# CP-20 PERMANENT CONCRETE — HAWTHORNE ROAD QUARRY

## LOCATION AND OWNERSHIP

The Hawthorne Road Quarry is located approximately 9 km south of Ottawa in Lot 28, Concession 6, City of Gloucester, Regional Municipality of Ottawa–Carleton (Figure CP–20–1). The quarry is owned by John Leonard and was opened in 1977 by G. W. Drummond Ltd. The quarry is currently licensed to Permanent Concrete, a division of Lafarge Canada Inc. The quarry licence covers an area of 40.46 ha.

## GEOLOGY

The 11.9 m deep quarry exposes sandstones, sandy dolostones and dolostones of the March Formation, which in turn are overlain by dolostones of the Oxford Formation. The quarry, which has been excavated into the hillside, has two lifts. Glacial overburden around the quarry is up to 2 m thick.

### Geological Section

| | | Thickness |
|---|---|---|
| *UNIT 6* | *Oxford Formation* | *5.1m* |

Dolostone: light to medium grey, weathers buff to dark grey; fine crystalline; medium bedded, with some thin, dark grey shale partings present between some beds; calcite-filled vugs occur in most beds; lower contact of unit sharp and planar.

| | | |
|---|---|---|
| *UNIT 5* | *March Formation* | *0.4m* |

Sandy dolostone: grey-brown, weathers medium grey; fine crystalline with medium- to coarse-grained quartz sand; slightly calcitic; single bed; calcite-filled vugs present; lower contact of unit sharp and planar.

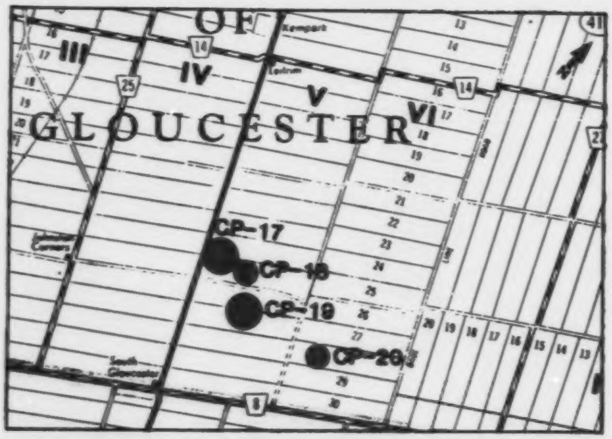


Figure CP-20-1. LOCATION MAP FOR HAWTHORNE ROAD QUARRY.

| | | |
|---|---|---|
| *UNIT 4* | *March Formation* | *0.3m* |

Sandstone: white to light grey, weathers white to reddish brown; fine to medium grained in a dolomitic cement; single bed; lower contact of unit sharp and planar.

| | | |
|---|---|---|
| *UNIT 3* | *March Formation* | *0.3m* |

Dolostone: grey-brown, weathers grey-green to buff; fine to medium crystalline; single bed; calcite-filled vugs common; lower contact of unit sharp and planar.

| | | |
|---|---|---|
| *UNIT 2* | *March Formation* | *0.3m* |

Sandstone: white to light grey, weathers white to reddish brown; fine to medium grained; single bed, small-scale crossbeds common; lower contact of unit sharp and slightly irregular.

| | | |
|---|---|---|
| *UNIT 1* | *March Formation* | *5.5m* |

Interbedded sandstone, sandy dolostone, and dolostone: grey-brown, some of sandstone is white, weathers same; fine- to medium-crystalline dolostone, with some beds containing medium- to coarse-grained quartz sand, interbedded with fine- to medium-grained sandstone: medium (10-20 cm) bedded, with sharp and planar contacts; calcite-filled vugs in some sandy dolostone and dolostone beds.

| | |
|---|---|
| *Total thickness* | *11.9m* |

## QUARRY OPERATION

The quarry has two lifts of about 6.1 m, the lower of which is presently being worked, and covers an area of about 10 ha. All drilling and blasting is contracted and a drill pattern of 2.1 m x 2.4 m with 7.6 cm diameter holes is used.

## PROCESSING

The flow sheet for the processing plant is shown on Figure CP–20–2. Stone is fed to the primary crusher, a portable 30 in. x 42 in. Hewitt–Robins jaw stationed in the quarry floor, by two Cat 988 loaders. The crusher has a capacity of 325 tonnes per hour and feeds two surge bins that lead to a Hewitt–Robins 5 ft. x 18 ft. triple–deck screen (two decks are used), or a 5 ft. x 14 ft. Cedarapids double–deck screen. The two screens produce –7/8 in. crusher run (Granular "A") to stockpile and +7/8 in. oversize that is fed to one of two Symons Standard 4 1/4 ft. cone crushers and returned to the surge bins. If required, the Granular "A" is fed to a Suntract 5 ft. x 14 ft. portable screening plant for separation into 3/4 in. clear, 3/8 in. clear, and dust.

Finished products are loaded into trucks by Cat 950 (3 yd.) and Komatsu (5.2 yd.) loaders and are used for both internal construction projects and commercial sales.

## PRODUCTS

2 in. Granular "B"
7/8 in. Granular "A"
3/4 in. Clear
3/8 in. Clear
Dust

Photo CP-20-1. CAT 988 FEEDING 30 IN. X 42 IN. HEWITT-ROBINS PRIMARY JAW CRUSHER AT THE HAWTHORNE ROAD QUARRY.

Photo CP-20-2. TWO SYMONS STANDARD 4 1/4 FT. CONE CRUSHERS IN PARALLEL CIRCUIT. CRUSHED STONE IS CONVEYED TO SURGE BIN; HAWTHORNE ROAD QUARRY.

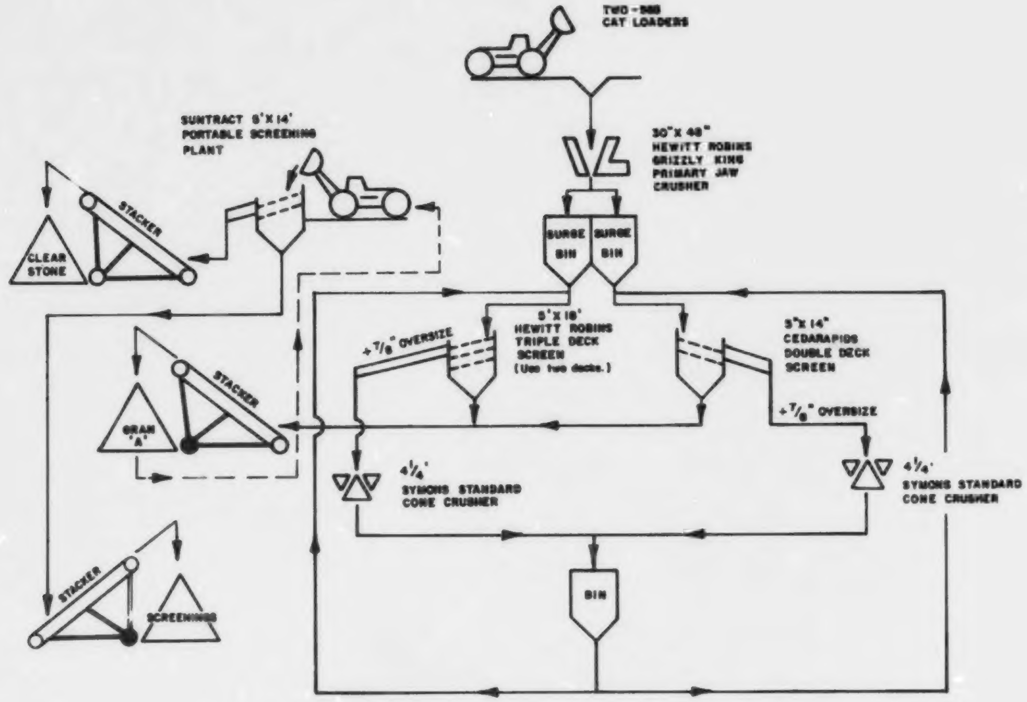

TWO-988 CAT LOADERS
30" X 48" HEWITT ROBINS GRIZZLY KING PRIMARY JAW CRUSHER
SUNTRACT 5' X 14' PORTABLE SCREENING PLANT
STACKER
CLEAR STONE
SURGE BIN
SURGE BIN
5' X 16' HEWITT ROBINS TRIPLE DECK SCREEN (Use two decks.)
5" X 14" CEDARAPIDS DOUBLE DECK SCREEN
$+7/8$" OVERSIZE
$+7/8$" OVERSIZE
STACKER
GRAN 'A'
$4\frac{1}{4}$' SYMONS STANDARD CONE CRUSHER
$4\frac{1}{4}$' SYMONS STANDARD CONE CRUSHER
STACKER
SCREENINGS
BIN

Figure CP-20-2. PROCESS FLOW SHEET FOR HAWTHORNE ROAD QUARRY.

## REFERENCES

Rogers, 1980, p.49–50
Williams, in prep., Appendix 1 – Section LQ OT–10

## MAPS

Williams, Rae and Wolf, 1984, OGS Map P.2716

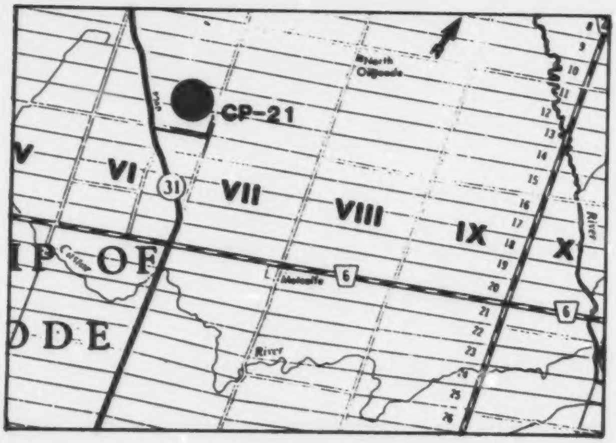
## CP–21 CORNWALL SAND & GRAVEL COMPANY — GREELY QUARRY

### LOCATION AND OWNERSHIP

This recently opened quarry, located 3 km south of Greely, in Lot 14, Concession 6, Osgoode Township, Regional Municipality of Ottawa–Carleton (Figure CP–21–1), is operated by Cornwall Sand & Gravel Company. The licensed property covers 20.24 ha.

### GEOLOGY

The 8.0 m deep quarry exposes medium–bedded, fine–crystalline dolostones of the Oxford Formation. Most beds contain at least a few large calcite–filled vugs; however, in some beds the vugs are numerous. Glacial overburden around the quarry is up to 3 m thick in places.


North Osgoode
CP-21
V
VI
31
VII
VIII
IX
X
IP OF
ODE
Metcalfe
6
6
River
River
8
9
10
11
12
13
14
15
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21
22
23
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25
26

Figure CP-21-1. LOCATION MAP FOR GREELY QUARRY.

## Geological Section

| | Thickness |
|---|---|
| *UNIT 2 Oxford Formation* | *2.2m* |
| Dolostone: medium grey, weathers dark grey-brown; fine crystalline; medium bedded (20 cm), with sharp, planar contacts; scattered small calcite-filled vugs present; lower contact of unit sharp and planar; this unit occurs as a bench, at the west side of the quarry, set back from the main quarry face. | |
| *UNIT 1 Oxford Formation* | *5.8m* |
| Dolostone: medium grey, weathers grey-brown; fine crystalline; medium (10-15 cm) bedded, with sharp, undulating contacts, some up to 5 cm of relief; scattered large (10 cm diameter) calcite-filled vugs present. | |
| *Total thickness* | *8.0m* |

### QUARRY OPERATION

The quarried stone is processed by a portable crushing system (see Richier Quarry CW-9 in the Cornwall District section).

### REFERENCES

None

### MAPS

None

## CP-22 FRANCON DIVISION OF CANFARGE LTD. — NORTH AND SOUTH (FRANCON) QUARRIES

### LOCATION AND OWNERSHIP

Two quarries, North and South, operated on this property, are located in Lots 12, 13 and 14, Concession 2, Gloucester Township, Regional Municipality of Ottawa–Carleton (Figure CP-22-1), just south of Highway 17 between Eastview and Orleans. The North and South Quarries were opened in 1948 by Ottawa Valley Crushed Stone and in 1967 by Francon, respectively. The quarry operations were initially located on the outskirts of Ottawa but over the years have been completely engulfed by city expansion. The operation produces all grades of asphalt, concrete and granular stone. The quarry licence covers an area of 100.73 ha.

### GEOLOGY

A 135 m thick stratigraphic succession from the lower member, Gull River Formation to the upper member,

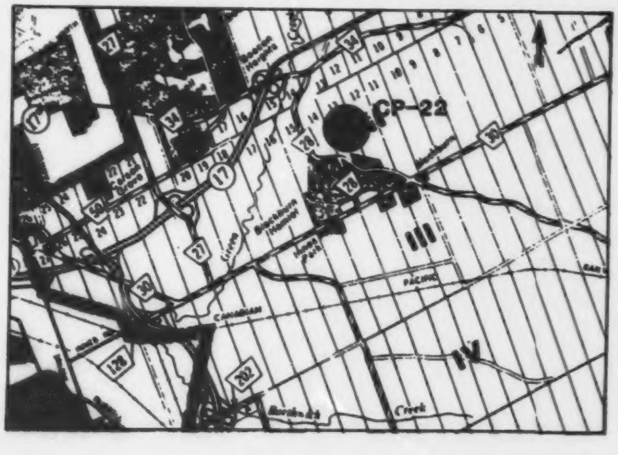
CP-22
17
34
27
30
28
174
202
III
IV
Canadian
Pacific
Creek

Figure CP-22-1. LOCATION MAP FOR NORTH AND SOUTH (FRANCON) QUARRIES.

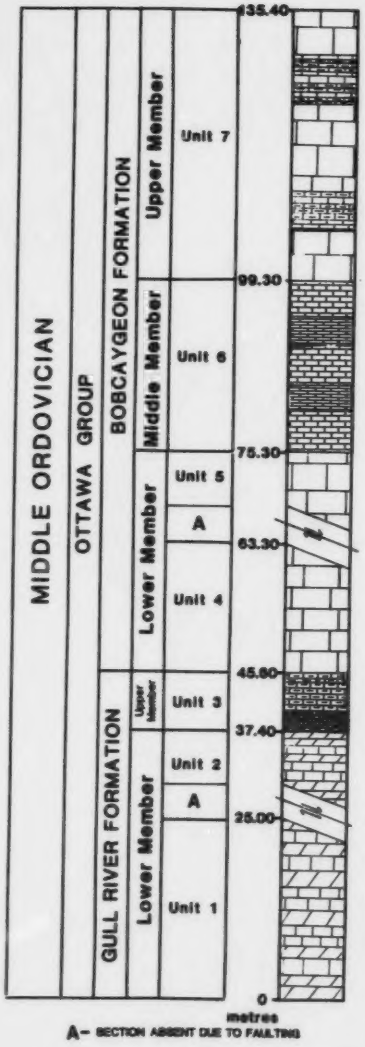
MIDDLE ORDOVICIAN
OTTAWA GROUP
BOBCAYGEON FORMATION
GULL RIVER FORMATION
Upper Member
Middle Member
Lower Member
Upper Member
Lower Member
Unit 7
Unit 6
Unit 5
A
Unit 4
Unit 3
Unit 2
A
Unit 1
135.40
99.30
75.30
63.30
45.60
37.40
25.00
0
metres
A– SECTION ABSENT DUE TO FAULTING

Figure CP-22-2. STRATIGRAPHIC COLUMN FOR NORTH AND SOUTH (FRANCON) QUARRIES.

Bobcaygeon Formation, is exposed in these quarries as a result of several, near-vertical normal faults (Figure CP–22–2, 22–3 and Table CP–22–1). Only two intervals (in the lower member, Gull River Formation and the lower member, Bobcaygeon Formation), have been cut out by the faulting. The stratigraphic succession exposed in these quarries can be correlated with the same interval in the G.S.C. Russell drill hole (Williams, in prep.).

The main fault exposed at this site lies along the southern boundary of Fault Block II (Figure CP–22–3) where the southern block has been downthrown by over 85 m. In the northeast corner of the South Quarry this fault is characterized by a 6 m wide breccia zone which contains large fragments of limestone and dolostone. Where a second fault branches off to the southeast at this spot, the intervening strata of Fault Block III dip to the south at about 30°. A second breccia zone, 3 m wide, occurs along the southern boundary of Fault Block III. The remaining faults are relatively minor and have no associated breccias, although some faults have adjacent drag folds. The anomalous movement (20 m north-side down of the southern fault) of Fault Block VII is the result of a significant rotation of this fault block.

Each fault block exposes about 20 to 30 m of section (Table CP–22–1) in two lifts in both of the North and South Quarries. The following summarizes the descriptions of each member exposed in these fault blocks.

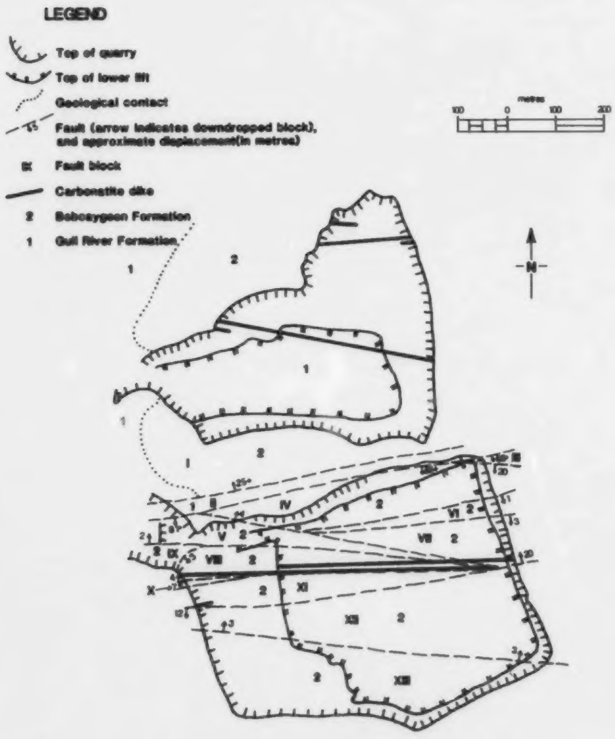

**Figure CP-22-3. GEOLOGICAL MAP FOR NORTH AND SOUTH FRANCON QUARRIES.**

## Geological Section

*Thickness*

*UNIT 7 Bobcaygeon Formation, upper member* *36.1m*

Alternating intervals of thin-bedded, shaly limestone and thick-bedded, shale-free limestone: medium to dark grey, weathers light grey, microcrystalline to fine crystalline, medium- to coarse-crystalline intervals in thicker bedded limestones; thin-bedded (5-10 cm) with thin (less than 1 cm), dark grey shale partings common, alternating with thick bedded (30-100 cm), shale free intervals; very fossiliferous, especially in shaly limestones, with abundant brachiopods, trilobites, bryozoans, and crinoidal debris.

*UNIT 6 Bobcaygeon Formation, middle member* *24.0m*

Limestone with shale interbeds: medium to dark grey, weathers light to medium grey; fine to coarse crystalline, with medium to coarse calcarenites in some beds; thin bedded (5-7 cm) with thin (1-2 cm), dark grey shale interbeds; small black chert nodules scattered in lower beds; very fossiliferous with abundant brachiopods, bryozoans and crinoidal debris.

*UNIT 5 and UNIT 4*

*Bobcaygeon Formation, lower member* *29.7m*

Limestone: medium to dark grey, grey-brown, weathers light grey, grey-brown; microcrystalline to fine crystalline; medium to massive bedded (50-120 cm) with rare thinner-bedded intervals, thickest beds most common in lower part of member; generally shale-free, but where present, shale commonly very thin and black; black chert nodules present in some beds; very fossiliferous, with abundant brachiopods, corals, bryozoans, trilobites and crinoidal debris.

*UNIT 3 Gull River Formation, upper member* *8.2m*

Limestone with shale partings: dark grey, weathers light to medium grey, or blue-grey; microcrystalline to very fine crystalline; thin to medium (5-30 cm) bedded with thin (less than 1-2 cm), dark grey shale partings between most beds; abundant small calcite crystals, "birdseye" texture; very fossiliferous, with abundant corals *(Tetradium)*, brachiopods and bryozoans.

*UNIT 1 and UNIT 2*

*Gull River Formation, lower member* *37.4m*

Alternating units of limestone and dolostone: Limestone: medium grey to light grey-brown, weathers light grey; microcrystalline, with some fine-crystalline beds; thin to thick bedded (5-50 cm) with rare, very thin shale partings; small calcite crystals, "birdseye" texture, common in some beds; moderately fossiliferous with brachiopods and bryozoans present;

Dolostone: dark grey-brown to light grey-green, weathers light grey-brown, brown and light grey-green; fine crystalline, with some beds in Fault Block II containing silt and sand; thin to medium bedded (5-25 cm); calcite filled vugs present in some beds; unfossiliferous; units range from 0.05 m to 2.5 m thickness.

*Total thickness* *135.4m*

## QUARRY OPERATION

The North Quarry has been excavated on two lifts of 20 m to 21.4 m and 10.7 m. Both lifts are currently advanc-

TABLE CP-22-1. FAULT BLOCK THICKNESSES, NORTH AND SOUTH (FRANCON) QUARRIES.

| FAULT BLOCK | | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII West | XII East | XIII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FORMATION | MEMBER | | | | | | | (metres) | | | | | | | |
| *BOBCAYGEON* | *UPPER* | | | 5.0 | 26.0<br>——<br>4.0 | 15.6 | 20.0<br>——<br>7.0 | 24.0<br>——<br>12.0 | 6.0 | | 5.0 | | 5.0 | 4.0 | 20.0 |
| | *MIDDLE* | | | 21.0<br>——<br>3.0 | 14.0 | 7.5<br>—— | 8.0 | 3.0 | 7.0<br>——<br>15.0 | 12.0<br>—— | 12.0<br>—— | 18.0<br>—— | 6.0<br>——<br>15.0 | 2.0<br>——<br>12.0 | ——<br>15.0 |
| | *LOWER* | 17.7 | | 12.0 | | | | | | | | 15.0 | | | |
| *GULL RIVER* | *UPPER* | 6.1<br>——<br>2.1 | | | | | | | | | | | | | |
| | *LOWER* | 12.4 | 25.0<br>—— | | | | | | | | | | | | |

——*Position of the top of the lower lift*

ing to the southwest; the first lift supplies concrete stone and the second lift supplies asphalt and granular base aggregates. All drilling and blasting is subcontracted and a 2.75 m x 2.75 m drill pattern is used with 7.6 cm diameter blast holes. A Cat 988B loader is used in the quarry with three Mack 35-ton trucks that haul approximately 500 m to the primary crusher.

The South Quarry is presently excavated on two lifts of 20 m to 21.4 m and 12.2 m with potential to develop an additional two lifts of 13.7 m each. Excessive overburden restricts the advance of the first lift. The South Quarry primarily supplies granular products.

## PROCESSING

Stone is crushed to -6 in. by a 48 in. x 36 in. Lipman jaw crusher (installed in 1967), and sent to a surge stockpile from where the crushed stone is drawn by three feeders to a tunnel conveyor belt and sent to a 4 1/4 ft. Symons cone crusher. The secondary crushed stone is then conveyed to the screenhouse where two 4 ft. x 12 ft. double-deck screens produce a +1 1/2 in. oversize that is fed to two 3 ft. Symons cone crushers and then returned to the 4 ft. x 12 ft. screens, and a -1 1/2 in. material that is fed to twin double-deck Dillon 5 ft. x 12 ft. screens. The screened products are stored in five bins and stockpiled by truck.

## PRODUCTS

The operation produces all grades of asphalt, concrete and granular stone.

## REFERENCES

Hewitt, 1960, p. 74-77
Hewitt, 1964a, p. 40
Hon, 1970, p. 24-27
Baird, 1972, p. 20-22
Hewitt and Vos, 1972, p.23-25
Rushforth, 1985
Hogarth and Rushforth, 1986, p. 9
Williams and Telford, 1986, p. 22
Williams, in prep., Appendix 1, Section LQ OT-11a, OT-116

## MAPS

Williams, Rae and Wolf, 1984, OGS Map P.2716

## CP-23 PERMANENT CONCRETE — NAVAN (LEBLANC) QUARRY

### LOCATION AND OWNERSHIP

The Navan Quarry is located approximately 2 km east of the village of Navan, in Lots 7, 8 and 9, Concession 6, Cumberland Township, Regional Municipality of Ottawa–Carleton (Figure CP–23–1). The quarry, formerly known as the Leblanc Quarry, was opened in the early 1970s by Laurent Leblanc and was purchased during the summer of 1986 by the present owner and operator, Permanent Concrete. The property is licensed for extraction on 176.03 ha and has an excavated area of 40 ha.

### GEOLOGY

The 21.0 m deep quarry exposes fine– to medium–crystalline, thin–bedded, nodular limestone of the lower member of the Lindsay Formation. The south face of the quarry exposes a small, near–vertical, normal fault which has a trend of 040°. The southeast side has a downthrow of approximately 1.0 m. Glacial overburden around the quarry is less than 2 m in thickness.

#### Geological Section

| | *Thickness* |
|---|---|
| *UNIT 1 Lindsay Formation, lower member* | *21.0m* |
| Limestone: medium grey, weathers light to medium grey; fine to medium crystalline; thin (5–10 cm) bedded, with dark grey, shale partings present, some 2–5 cm thick; most beds display a faint nodular texture, beds at top of quarry weather into nodular, rubbly horizons; some limestone beds contain light grey, fine-crystalline limestone intraclasts; very fossiliferous, with abundant brachiopods, trilobites, corals, and crinoidal debris, burrows also common. | |
| *Total thickness* | *21.0m* |

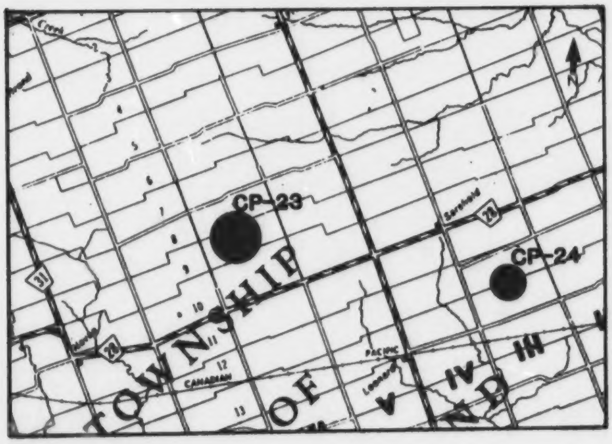

Figure CP-23-1. LOCATION MAP FOR NAVAN (LEBLANC) QUARRY.

### QUARRY OPERATION

The quarry is opened on two lifts of 12 m and 9 m. The top lift (12 m) is used to supply concrete stone products and the bottom lift mainly supplies crusher run material. Lower lifts are available for future extraction. Drilling and blasting is contracted and a 2.44 m x 2.44 m drill pattern with 7.6 cm diameter blast holes is used. Blasted stone is loaded by two Cat 992 loaders for haulage to the primary crusher, a Pioneer 4654 impact crusher that feeds a Canica 105 vertical shaft secondary crusher. A Pioneer 8 ft. x 20 ft. triple–deck/Eljay 5 ft. x 16 ft. double–deck screening plant is currently used.

### PROCESSING

A sequence of drilling/blasting and crushing alternates from lower to upper lifts which are presently worked at opposite ends of the quarry. After blasting approximately 150,000 tons, the portable crushing units are moved close to the stone pile and drilling is resumed at the alternate quarry lift.

### PRODUCTS

Armour Stone
Gabion Stone 3 in. to 6 in.
Granular "A", "B" and "C"
1 1/4 in. Clear – Septic Bed Stone
3/4 in. Concrete Stone
3/8 in. Chips
1/4 in. Dust

### REFERENCES

Williams, in prep., Appendix 1 – Section LQ RU–1

### MAPS

Williams, Rae and Wolf, 1985c, OGS Map P.2717

## CP-24 BERTRAND & FRERES CONSTRUCTION COMPANY LTD. — SARSFIELD QUARRY

### LOCATION AND OWNERSHIP

The Sarsfield Quarry is located 1 km southeast of Sarsfield, in Lot 12, Concession 3, Cumberland Township, Regional Municipality of Ottawa–Carleton (Figure CP–24–1), and was opened in 1979 by the owner and operator, Bertrand & Freres Construction Company Ltd. The quarry is licensed for an area of 22.25 ha.

### GEOLOGY

The 13.0 m deep quarry exposes fine– to medium–crystalline, thin–to medium–bedded, nodular limestones of the lower member of the Lindsay Formation. Glacial overburden around the quarry is less than 1 m thick.

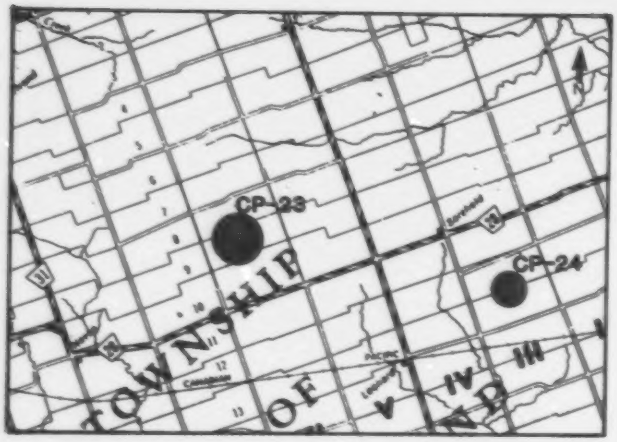

Figure CP-24-1. LOCATION MAP FOR SARSFIELD QUARRY.

### Geological Section

| | | Thickness |
|---|---|---|
| UNIT 1 | *Lindsay Formation, lower member* | 13.0m |

Limestone: light to medium grey, weathers light grey-brown to brown; fine to medium crystalline; thin to medium bedded, with shale partings up to 5 cm common between beds; fine-crystalline limestone intraclasts present in some beds; fossiliferous, with abundant brachiopods, corals, and crinoidal debris.

*Total thickness* 13.0m

### QUARRY OPERATION

In 1986, the quarry produced weeping bed stone and granular stone that was used for local road, bridge and subdivision construction.

### REFERENCES

Williams, in prep., Appendix 1 – Section LQ RU-3

### MAPS

Williams, Rae and Wolf, 1985c, OGS Map P.2717

## CP-25 STEEP ROCK CALCITE – TATLOCK QUARRY

### LOCATION AND OWNERSHIP

Steep Rock Calcite, a division of Steep Rock Resources Inc., operates a high purity calcite quarry in Lots 4, 5 and 6, Concession 3, 4 and 5, Darling Township, Lanark County, near the village of Tatlock some 40 km north of Perth (Figure CP-25-1). The quarry property covers about 280 ha; part is located on private land, the remainder on Crown land.

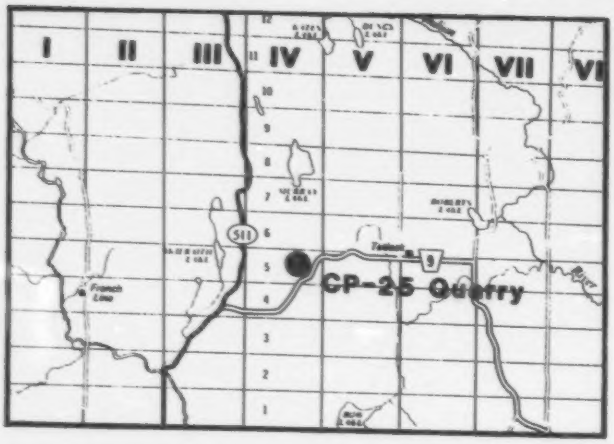

Figure CP-25-1. LOCATION MAP FOR TATLOCK QUARRY.

The deposit contains in excess of 6 million tonnes of high purity white crystalline calcite and includes two former building stone quarries previously held by Angelstone Ltd. and Omega Marble Tile and Terrazzo Ltd. (Hewitt 1964c, p. 61, 64).

### GEOLOGY

A white, medium crystalline calcite at this quarry was described by Hewitt (1964c, p. 62). Details of the geology in the quarry mapped by C. Fox, consulting geologist, were kindly made available by the company. In plan, a series of parallel zones of calcite with different silica* content are shown trending to the north. A wide belt of low silica* content (less than 3%) is bounded by dolomite to the west and by zones with higher silica* content (3% – 11%) to the east. The latter zones underlie the initial quarry which produced crushed calcite of high brightness but limited use as calcite filler. In cross section the parallel zones or beds of calcite are shown to dip eastward at approximately 55°. This dip is variable on the property within limits of 40° to 70°.

The low silica zone reaches true thicknesses of 85 m. Here the calcite is white, medium to coarse crystalline, with negligible phlogopite and essentially free of graphite.

The footwall boundary is determined by impure dolomitic material with increased silica content and inclusions of boudinaged amphibolite. Rare boudinaged quartz veins cross cut the marble belt.

Along strike the calcite is also limited by higher silica content. Quartz and tremolite are the major silicate minerals. The presence of phlogopite and diopside (Hewitt 1964c, p. 66) has also been recorded.

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* *The use of the term silica includes silica in the form of both quartz and various silicate minerals.*

Reserves of high purity calcite remaining in the present orebody are calculated to be 6.8 million tonnes to a depth of 61 m. Available reserves would be substantially increased if shown to continue below the present quarry design and if amenable to underground mining, and by beneficiation of the material with higher silica content. Additional deposits of high quality calcite have been indicated by exploratory drilling to the west and northwest of the present orebody within the limits of the existing claim group.

## QUARRY OPERATION

The quarry is operated only during the summer months. The drilling, blasting, pit haulage, primary and secondary crushing is performed by a mining contractor and the crushed rock, essentially $-1^1/_2$ in., is transported to the processing plants located on the south side of Highway 7 just west of Perth (Figure CP-25-2).

## PROCESSING

The delivered stone is stockpiled at the plant in amounts sufficient to provide feed for the full operating year. The Perth plant has an annual capacity of 250,000 tonnes. The primary crushed rock stockpile is covered with a special reinforced vinyl cover, which protects the ore from excessive rain and snow.

Steep Rock operates three separate but interconnected production facilities with each plant making its own range of products. The first plant consists of a drying operation, using an oil fired rotary drier, that processes all the crushed rock required for "dry processed" filler products. Dried stone is screened in the first plant or screen house into a range of closely sized granular products or diverted to provide feed material for the dry process filler plant.

Screen oversize products are recirculated to a Hazemag impact crusher operating in closed circuit with the screening operation. The plant also has the facility to air classify granular products to remove undesirable fines

Photo CP-25-1.
VIEW OF TATLOCK QUARRY.

from the screened products. These fines have a controlled size and are used in several filler applications.

Granular products are held in individual storage bins adjacent to the screening plant, from where they can be loaded directly into trucks or carried by pneumatic conveyor to the "dry process" filler plant or to the bagging plant for packing in 50 lb. paper bags.

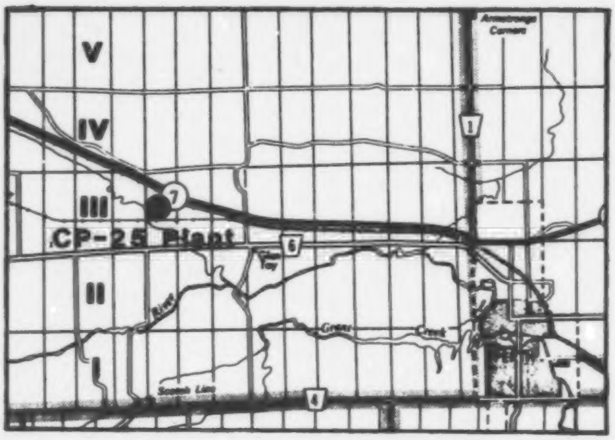


Figure CP-25-2. LOCATION MAP FOR STEEP ROCK RESOURCES PLANT.

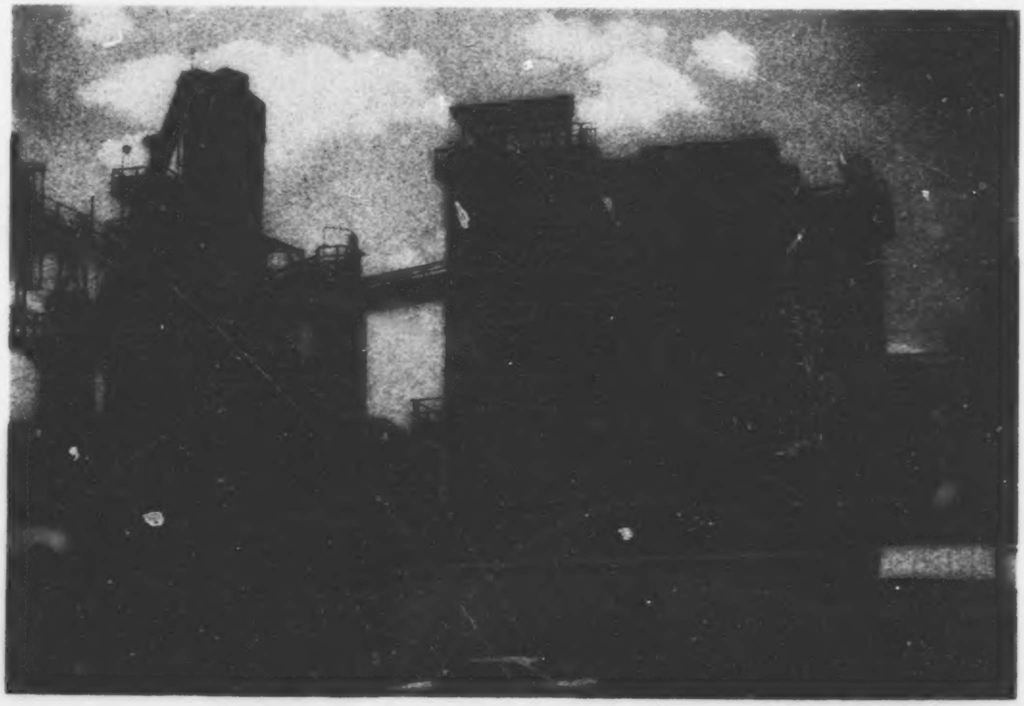
### Medium Fine and Fine Grind Products

Part of the dried −3/4 in. stone is conveyed to a bulk storage silo, feeding a 5 1/2 ft. Raymond roller mill. This mill, with its own internal classifier, produces coarse and medium fine filler products and granular feed for a 10 ft. x 7 ft. Koppers–Hardinge pebble mill. This mill uses ceramic liners and fused alumina grinding media, and operates in closed circuit with a Hardinge gyrotor classifier, to produce medium fine products ranging from 84% to 99.5% passing 325 mesh (44 micron).

Medium fine products are further classified with two highly efficient air classifiers to produce fine filler products ranging from 30 micron topsize down to a product with a 10 micron topsize.

Products are stored in six large "mass flow" 120–ton storage bins, located adjacent to the grinding plant, from which bulk trucks can be loaded directly. It is also possible to transfer products from these silos by separate pneumatic conveyors to several bagging stations. Conveying of intermediate or finished product in the plant is by dust tight airslides or pneumatic conveyors. Dust collectors are installed in the plant to remove process dust at points where products are exposed to atmosphere on storage silos, loading facilities and bagging operations.

Photo CP-25-2. STEEP ROCK RESOURCES, FINE GRINDING PLANT, PERTH.



Bagged products are stored by grade in a large warehouse with truck loading docks.

The dry process plant is operated from a large central control room. Many of the process functions are automated but are under full control of the operator. The plant is operated year round, three shifts per day, excluding scheduled maintenance shifts.

In 1985, Steep Rock Resources Inc. and a Canadian affiliate of Georgia Kaolin Company, Inc. concluded a joint venture agreement for the construction and operation of an ultra fine calcium carbonate plant at Perth. The objective is to produce high purity, high brightness ultra–fine particle calcium carbonate. The processes involved are proprietary, using a beneficiation process as well as highly specialized super fine grind technology developed by Georgia Kaolin Company, Inc.

The latter plant came into production in early 1987, producing high solids slurried calcium carbonate paper filler and coating products through wet processing methods. The joint venture sales agency operates under the name Ontario Carbonate Ltd.

## PRODUCTS

### Coarse Product

A range of coarse materials are produced by passing the $-1^1/_2$ in. stone through a portable screening plant, e.g. landscape chips, exposed aggregates, precast concrete stone, terrazzo chips, fertilizer diluents, poultry grits and agricultural limestone.

### Granular Products

Products from the #1 plant screen house range from 6 x 16 mesh, 12 x 40 mesh to 40 mesh products. Excess fines are removed by the air classifiers located in plant #1 screen house. Granular products are used in such applications as stucco mix, cultured marble products, floor tile and animal feed supplements.

### Medium Fine Products

Products from the Raymond mill and medium fine products from the pebble mill circuit are used in floor tile, wall jointing compounds, architectural textured coatings, adhesives and traffic paints.

### Fine Products

Fine calcium carbonate filler products ranging from nominal top sizes of 30, 20 and 10 microns are used in interior paints, rubber, polyvinyl chloride, polyesters and adhesives. Calcium carbonate is a very functional filler and is non–reinforcing except when coated with organic additives such as coupling agents. As such it is a "prime" resin stretcher in plastics, reducing the cost of the manufactured product because of its own relatively low cost. Its natural high brightness also contributes to maintain clean colours in pigmented products. In paints it is used primarily as a pigment extender in conjunction with $TiO_2$.

### REFERENCES

Hewitt, 1964c, p. 61–66

### MAPS

none

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*Note: At the time of printing, the operations and shares of Steep Rock Calcite were being purchased by MAS Minerals Corp., a wholly owned subsidiary of Pluess–Stauffer AG of Switzerland.*

# Brockville District

## INTRODUCTION

The Brockville District is situated in the Eastern Region of southern Ontario lying immediately west and south of Cornwall and Carleton Place Districts, respectively. The St. Lawrence River defines the southern extent of the district which is bounded on the west by the Napanee District.

Forty-three quarry properties have been documented in the Brockville District quarry inventory (Appendix IV, Volume I); five are currently active, ten operate intermittently and the balance represent past producing quarries of geological significance.

All of the principal quarries currently in either full or intermittent production were visited during the study and include the following:

| | |
|---|---|
| *BR-1* | *Griffin Bros. (Gananoque) Ltd. - Westport Quarry (active)* |
| *BR-2* | *G. Tackaberry and Sons Construction Company Limited - Harlem Quarry (intermittent)* |
| *BR-3* | *G. Tackaberry and Sons Construction Company Limited - O'Grady Quarry (intermittent)* |
| *BR-4* | *O. Shirley and Sons Quarry (intermittent)* |

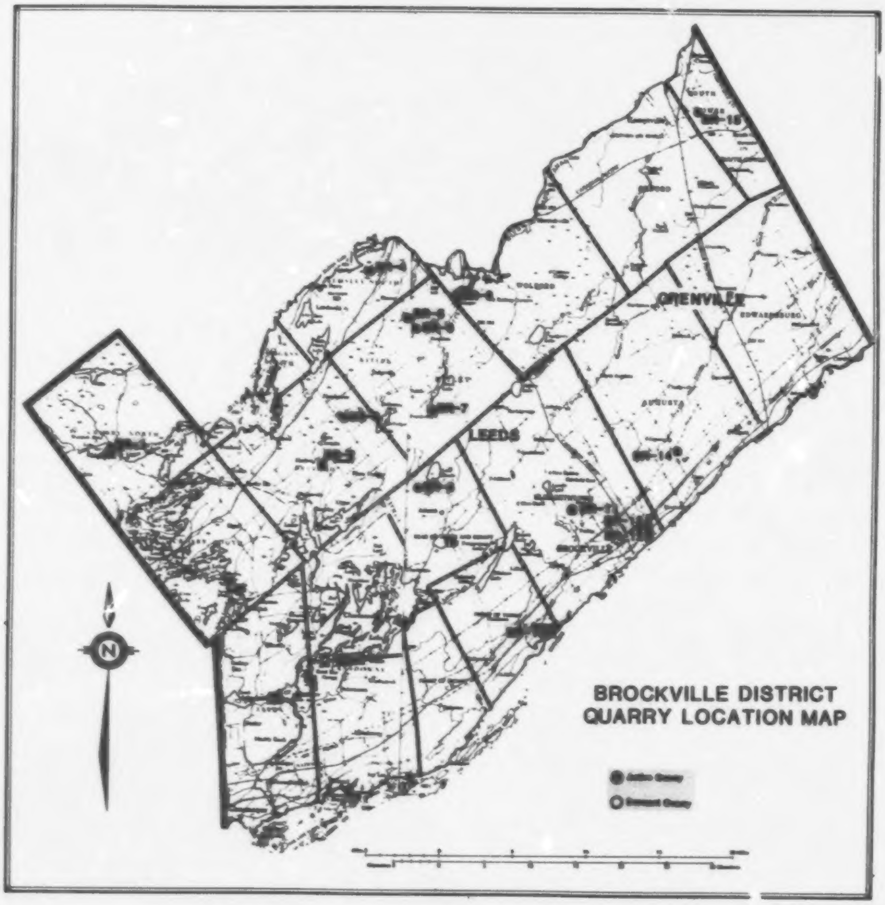


Figure BR-0-1. BROCKVILLE DISTRICT QUARRY LOCATION MAP.

| | |
|---|---|
| *BR-5* | *G. Tackaberry and Sons Construction Company Limited - Willows (Newbliss) Quarry (intermittent)* |
| *BR-6* | *G. Tackaberry and Sons Construction Company Limited - Ronan (Leeds) Quarry (intermittent)* |
| *BR-7* | *G. Tackaberry and Sons Construction Company Limited - Mercier (Frankville) Quarry (intermittent)* |
| *BR-8* | *G. Tackaberry and Sons Construction Company Limited - Lawson (Athens No. 2) Quarry (active)* |
| *BR-9* | *G. Tackaberry and Sons Construction Company Limited - Jasper Quarry (active)* |
| *BR-10* | *William Clow - Sherwood Springs Quarry (intermittent)* |
| *BR-11* | *G. Tackaberry and Sons Construction Company Limited - Woods (Tincap) Quarry (active)* |
| *BR-12* | *Permanent Concrete - Brockville Quarry (active)* |
| *BR-13* | *Warren Paving and Materials Group Ltd. - Brockville Quarry (intermittent)* |
| *BR-14* | *G. Tackaberry and Sons Construction Company Limited - Wings (Maitland) Quarry (intermittent)* |
| *BR-15* | *Maple Grove (Kemptville) Ltd. - Kemptville Quarry (intermittent)* |

## REGIONAL GEOLOGY

The Brockville District extends northward from the St. Lawrence River, between Gananoque and Cardinal to the Rideau River–Rideau Lakes system (Figure BR–0–1), and encompasses all of Leeds and Grenville Counties. The main geomorphic features in the district include the Frontenac Axis, the Precambrian highlands to the west and the flat plains to the east underlain by Paleozoic strata.

Glacial overburden is essentially absent in the western and central parts of the district. Thick Quaternary deposits, however, occur in the eastern part of the district, especially around the Kemptville area in the northeast.

The Brockville District is underlain by Precambrian and Lower to Middle Ordovician rocks. The Precambrian rocks outcrop to the west where the southeastward extension of the Canadian Shield, the Frontenac Axis, crosses the St. Lawrence River at the Thousand Islands and joins with the Adirondack Mountains of New York State. Several small operations near Gananoque extract granitic rocks for ornamental and armour stone.

Unlike most of Central Ontario, the Paleozoic rocks of Eastern Ontario have been disrupted by large–scale faults (Williams, in prep.). In the Brockville District one of the major faults is the Rideau Lake Fault which trends northeast from Westport to Smiths Falls. Smaller–scale faults also occur although most, especially those which occur within the Oxford Formation, have such small displacements that only actual exposures reveal their presence.

The Paleozoic strata underlying the district consist of Lower to Middle Ordovician clastic and carbonate rocks (Figure BR–0–2). The following formations are present (in ascending order): the Covey Hill and Nepean Formations of the Potsdam Group (the lower part of which may be Cambrian in age), the March and Oxford Formations of the Beekmantown Group, the Rockcliffe Formation, and the Shadow Lake and Gull River Formations of the Ottawa Group (Williams, in prep.).

The Potsdam Group consists of the conglomerates and arkoses of the Covey Hill Formation and the overlying quartz arenites of the Nepean Formation. Small operations currently utilize this stone for aggregate and dimensional stone. Historically, the sandstones of the Nepean Formation have been used extensively as building material as, for example in the Parliament Buildings in Ottawa.

The overlying Lower Ordovician Beekmantown Group consists of the March and Oxford Formations. The March Formation is transitional from the clastic rocks of the Potsdam Group to the overlying dolostones of the Oxford Formation and thus consists of alternating beds of quartz arenite and dolostone, with gradations between the two rock types. Most common are fine–crystalline dolostones which consist of up to 50% medium– to coarse–grained, well rounded quartz grains, which "float" in the dolostone. The lower contact of the March Formation is placed at the base of the lowest dolostone bed (Williams, in prep.). The formation thickens from its erosional edge in the west to an average thickness of 15 to 20 m in the east.

The March Formation has been quarried extensively over the years. Large blocks of sandy dolostone were utilized in the construction of the Rideau Canal system in the 1830s. Dolostone and sandy dolostone beds were also quarried for building and ornamental stone. In addition to being a source for crushed stone, the sandy dolostone beds have proven to be an excellent source of skid–resistant aggregate (Rogers, 1980). The currently active quarries, which are entirely within the March Formation, are the O'Grady (BR–3), O. Shirley (BR–4), Mercier (BR–7), Lawson (BR–8), and Sherwood Springs (BR–10) Quarries. The March Formation is also exposed at the base of the Harlem (BR–2) and Brockville (BR–12) Quarries.

The Oxford Formation consists of grey–brown, fine–crystalline, medium–bedded dolostones which may vary from microcrystalline to medium crystalline and thin to thick bedded. Scattered, coarse–grained quartz sand and

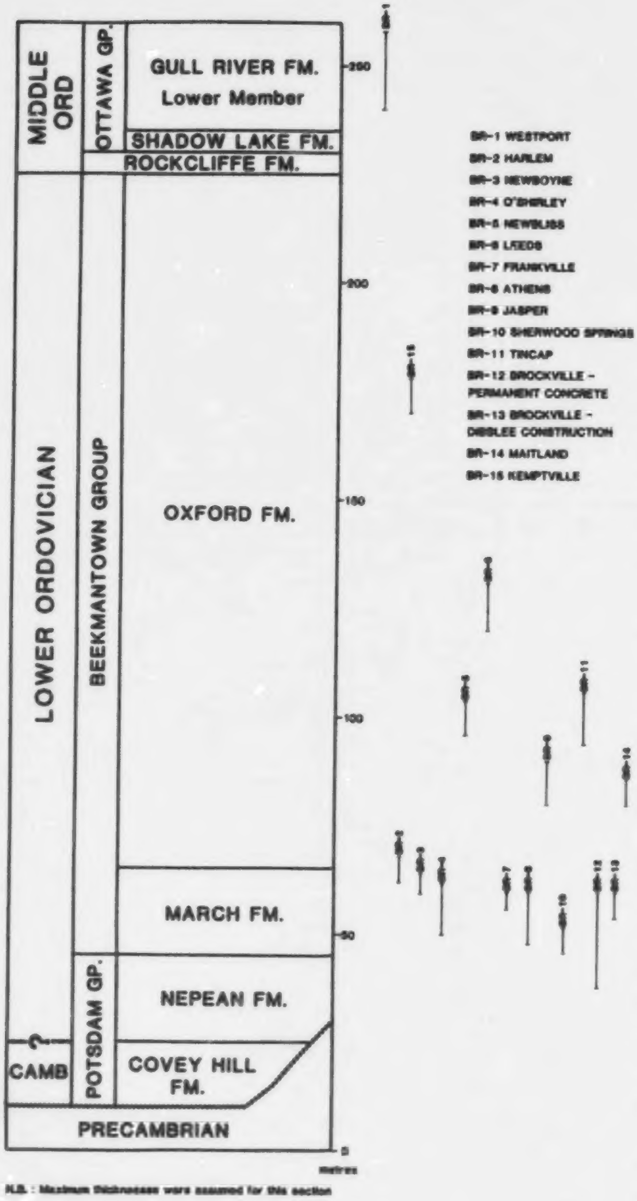

MIDDLE ORD
LOWER ORDOVICIAN
CAMB
OTTAWA GP.
BEEKMANTOWN GROUP
POTSDAM GP.
GULL RIVER FM.
Lower Member
SHADOW LAKE FM.
ROCKCLIFFE FM.
OXFORD FM.
MARCH FM.
NEPEAN FM.
COVEY HILL FM.
PRECAMBRIAN
?
250
200
150
100
50
0
metres
BR-1 WESTPORT
BR-2 HARLEM
BR-3 NEWBOYNE
BR-4 O'SHERLEY
BR-5 NEWBLISS
BR-6 LEEDS
BR-7 FRANKVILLE
BR-8 ATHENS
BR-9 JASPER
BR-10 SHERWOOD SPRINGS
BR-11 TINCAP
BR-12 BROCKVILLE - PERMANENT CONCRETE
BR-13 BROCKVILLE - DIBBLEE CONSTRUCTION
BR-14 MAITLAND
BR-15 KEMPTVILLE
N.B.: Maximum thicknesses were assumed for this section

Figure BR-0-2. STRATIGRAPHIC COLUMN SHOWING PRINCIPAL QUARRIES OF BROCKVILLE DISTRICT.

sandy interbeds (up to 30 cm thick) are present in the lower part of the formation. Calcite-filled vugs, of varying sizes, are common in some intervals as are small, white chert nodules. The lower contact of the Oxford Formation is placed at the top of the uppermost sandstone bed in the underlying March Formation (Williams, in prep.). The formation thickens from its erosional edge to a thickness of over 180 m at the eastern edge of the district.

Most of the Brockville District is underlain by the flat-lying dolostones of the Oxford Formation, usually with less than 1 m of overburden. Many quarries have been developed in these dolostones, primarily as aggregate sources. The principal active quarries in the Oxford Formation in the district (Figure BR-0-2) include the Jasper (BR-9) and Brockville – Permanent Concrete (BR-12) Quarries, two of the larger crushed stone operations. In addition there are numerous abandoned quarries in the Oxford Formation across the district (Appendix IV, Volume I).

In the Westport area, an outlier of Middle Ordovician strata (Figure BR-0-1) is currently being quarried for crushed stone by Griffin Brothers (Gananoque) Ltd. at the Westport Quarry (BR-1) (Figure BR-0-1). Dolostones and limestones of the lower part of the lower member of the Gull River Formation are exposed in this quarry. The dolostones, which contain silty intervals, commonly are buff to light brown, fine crystalline, and thin to thick bedded with thin shale partings between the beds. The limestones are generally light grey, microcrystalline to fine crystalline, thin to thick bedded, and are often mottled with light brown dolomitized burrows. Small calcite- and gypsum-filled nodules occur in some limestone beds. A shallow drillhole (collared 0.46 m above the quarry floor) intersected (in descending order): 4.6 m of limestone and dolostone of the lower member, Gull River Formation; 2.8 m of shale and shaly dolostone assigned to the Shadow Lake Formation; 1.5 m of green shale assigned to the Rockcliffe Formation; 3.8 m of dolostones of the Oxford Formation; 8.9 m of sandy dolostone of the March Formation; and terminated 10.5 m into the quartz arenites of the Nepean Formation (D.A. Williams, written communication, 1987). The thin interval of the Oxford Formation reflects the influence of the major unconformity between the Lower and Middle Ordovician.

The Westport Quarry (BR-1) is the only active quarry in the Middle Ordovician outlier near Westport, although a few small abandoned quarries were found in the area (Appendix IV, Volume I).

## LIMESTONE INDUSTRIES

Aggregate production is the principal limestone industry in the Brockville District. In 1985 and 1986 stone production from the United Counties of Leeds and Grenville, was approximately 660,000 tonnes and 671,000 tonnes, respectively, and was used by the construction industry as road, asphalt and concrete aggregate.

The largest single producer in the District is G. Tackaberry and Sons Construction Company Limited reporting production not only from their currently active Lawson (BR–8) and Jasper (BR–9) quarries but also from eight intermittently operated quarries including Harlem (BR–2), O'Grady (BR–3), Willows (BR–5), Ronan (BR–6), Mercier (BR–7), Woods (BR–11) and Wings (BR–14) quarries. The second largest active producer in the district is Permanent Concrete–Brockville Quarry (BR–12) followed by Warren Paving and Materials Group Limited–Brockville Quarry (BR–13). The remaining quarries including Westport (BR–1), O. Shirley and Sons (BR–4), Sherwood Springs (BR–10), and Kemptville (BR–15) operate on an intermittent basis usually providing stone for a specific project.

## BR-1 GRIFFIN BROS. (GANANOQUE) LTD. — LYNN (WESTPORT) QUARRY

### LOCATION AND OWNERSHIP

The Westport Quarry is located in Lot 12, Concession 7, North Crosby Township, United Counties of Leeds and Grenville, 1.5 km southwest of Westport on Highway 42 (Figure BR–1–1). The quarry was opened during the mid–1960s and licensed in 1981 for extraction over an area of 12.7 ha. The Lynn Quarry is operated by Griffin Bros. (Gananoque) Ltd. The quarry products are primarily used for local township road maintenance and construction.

### GEOLOGY

The 16.7 m deep quarry exposes limestones and dolostones of the lower member of the Gull River Formation (Figure BR–1–2). The limestone beds are often mottled with dolomitized burrows or indistinct patches. Most of the limestone is light to dark grey, thin to medium bedded and microcrystalline. The medium–bedded, fine–crystalline dolostones usually weather a light brown or green and often contain vugs. In addition to the numerous calcite–filled vugs, some vugs are filled with gypsum. Shale interbeds are present in the upper 10 m of the quarry. Glacial overburden varies considerably both adjacent to and on top of the quarry, but is commonly 3 to 4 m in thickness.

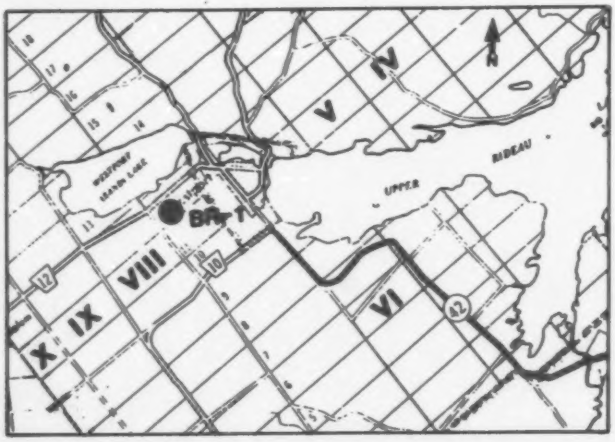


Figure BR-1-1. LOCATION MAP FOR WESTPORT QUARRY.

### Geological Section

| | | *Thickness* |
|---|---|---|
| *UNIT 3* | *Gull River Formation, lower member* | *9.9m* |

Dolostone, with limestone interbeds: light grey–green to dark grey, weathers buff to red–brown; fine to medium crystalline, with some silty intervals, and microcrystalline limestone beds; thin to thick bedded (limestone interbeds up to 35 cm thick) with thin shale partings and shale interbeds up to 10 cm thick; calcite and gypsum filled vugs common, gypsum molds are present in limestone; sparsely fossiliferous; lower contact of unit sharp and planar.

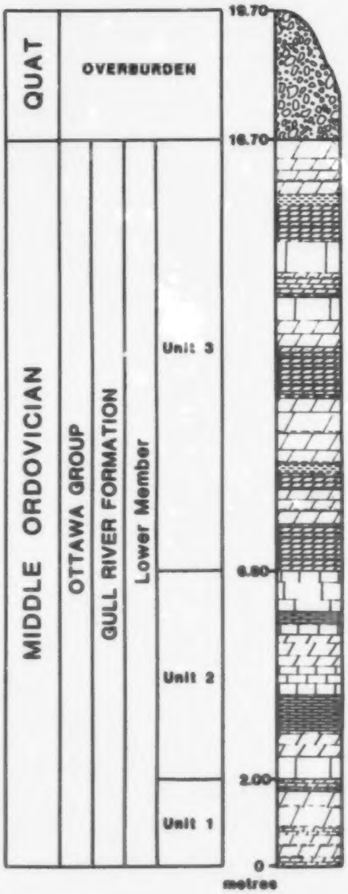


Figure BR-1-2. STRATIGRAPHIC COLUMN FOR WESTPORT QUARRY.

*UNIT 2 Gull River Formation, lower member 4.8m*

Limestone, with dolomitic mottling and dolostone interbeds: medium to dark grey, weathers light to medium grey; microcrystalline to fine crystalline; thin to thick bedded with dolostone interbeds up to 25 cm thick; dolostone intraclasts are present in limestone beds at the base; oolitic limestone present in several intervals; gypsum nodules present in limestones; lower contact of unit sharp and planar.

*UNIT 1 Gull River Formation, lower member 2.0m*

Dolostone, with shale partings: light grey-green, weathers buff; fine crystalline with some silt present; thin to thick bedded; slightly calcitic; conchoidal fractures common; sparsely fossiliferous with scattered brachiopods.

*Total thickness 16.7m*

### QUARRY OPERATION

The Westport Quarry presently covers an area of approximately 300 m x 500 m. The stone is quarried by drilling and blasting with production being derived from a single 8 m to 11 m lift. To achieve optimum fragmentation 6.4 cm blast holes are drilled in a 2.1 m x 2.1 m pattern.

### PROCESSING

The broken rock is delivered to a portable Cedarapids 30 in. x 42 in. double impeller primary crusher which is in series with a Cedarapids 896 Commander secondary crusher. The main products are 4 in. and 5/8 in. crusher run stone. During the summer of 1986 stone from the Westport Quarry was used to construct a local airstrip for service aircraft involved in the MNR gypsy moth spraying program.

### REFERENCES

Williams, in prep., Appendix 1 – Section LQ WE-6

### MAPS

Williams and Wolf, 1984c, OGS Map P.2723

## BR-2 G. TACKABERRY AND SONS CONSTRUCTION COMPANY LIMITED – HARLEM QUARRY

### LOCATION AND OWNERSHIP

The Harlem Quarry, which was not in operation at the time of the field work in June 1986, is located in Lot 15, Concession 6, Bastard Township, United Counties of Leeds and Grenville, 1 km south of Harlem (Figure BR-2-1). The quarry is licensed for 5.1 ha and is intermittently operated by G. Tackaberry and Sons Construction Company Limited.

### GEOLOGY

The 3.7 m deep quarry exposes sandy dolostones and sandstones of the March Formation and the overlying dolostones of the Oxford Formation. The strata of the March Formation consist of fine-crystalline dolostone with medium-to coarse-grained quartz grains scattered throughout. Some beds are fine- to medium-grained sandstones with a dolomitic cement. The dolostones of the Oxford Formation are medium bedded and fine crystalline. The contact between the two formations is well exposed in this quarry. Glacial overburden around the quarry is very thin.

### Geological Section

*Thickness*

*UNIT 3 Oxford Formation 2.4m*

Dolostone: light grey-brown, weathers same; fine crystalline, minor fine-grained quartz; medium bedded (15-25 cm); small calcite filled vugs common in some beds; the lower 25 cm is a distinctive, very thin-bedded dolostone; lower contact of unit sharp and planar.

*UNIT 2 March Formation 0.2m*

Sandstone: green to light grey; weathers light brown to medium grey; coarse grained; slightly calcareous cement; single bed; lower contact of unit sharp and planar.

*UNIT 1 March Formation 1.1m*

Dolostone, sandy: light brown, weathers medium grey; fine crystalline with scattered coarse grains of quartz sand; very thin to thin bedded (2-8 cm); lower 5 cm is a sandy dolostone with coarse grained, well rounded quartz grains.

*Total thickness 3.7m*

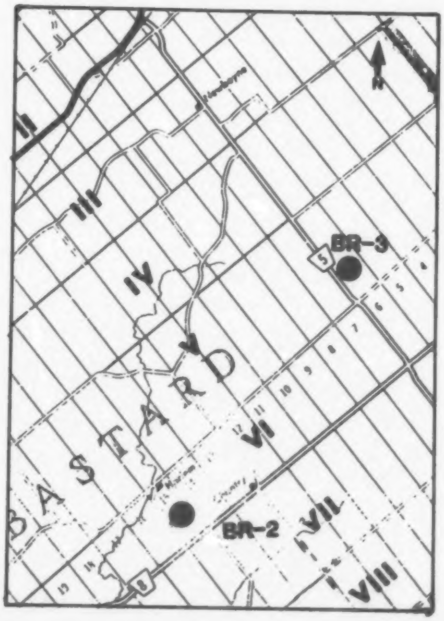


**Figure BR-2-1. LOCATION MAP FOR HARLEM QUARRY.**

### REFERENCES

Hewitt, 1964a, p. 20–21

Hewitt and Vos, 1972, p. 10

Rogers, 1980, p. 58

Williams, in prep., Appendix 1 – Section LQ WE–2

### MAPS

Williams and Wolf, 1984c, OGS Map P.2723

## BR–3 G. TACKABERRY AND SONS CONSTRUCTION COMPANY LIMITED — O'GRADY QUARRY

### LOCATION AND OWNERSHIP

The O'Grady Quarry is intermittently operated by G. Tackaberry and Sons Construction Company Limited and is located 3.5 km southeast of Newboyne in Pt. Lot 6, Concession 5, Bastard Township, United Counties of Leeds and Grenville (Figure BR–3–1). The property is licensed for 25.5 ha.

### GEOLOGY

The 3.8 m deep quarry exposes medium–bedded dolostones, sandy dolostones and sandstones of the March Formation. Glacial overburden around the quarry is very thin.

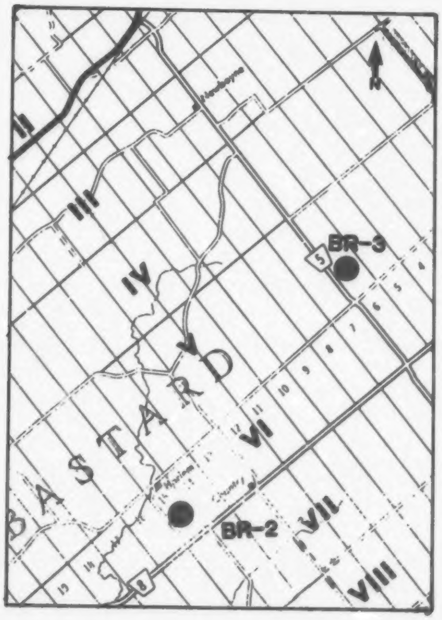


**Figure BR–3–1. LOCATION MAP FOR O'GRADY QUARRY.**

### Geological Section

*Thickness*

*UNIT 3 March Formation* *3.0m*

Dolostone, sandy: light brown–grey, weathers same; fine crystalline with medium–grained quartz; medium bedded (10–30 cm); calcite filled vugs are present; lower contact of unit is sharp and planar.

*UNIT 2 March Formation* *0.3m*

Sandstone: light green, weathers same; very coarse grained, well sorted, well–rounded quartz grains; single bed; calcareous cement; lower contact of unit covered.

*Covered Interval* *0.4m*

*UNIT 1 March Formation* *0.1m*

Dolostone: light grey–brown, weathers light brown; fine crystalline, this unit exposes only the uppermost part of a thicker bed.

*Total thickness* *3.8m*

### REFERENCES

Williams, in prep., Appendix 1 – Section LQ WE–3

### MAPS

Williams and Wolf, 1984c, OGS Map P.2723

## BR–4 O. SHIRLEY AND SONS — SHIRLEY QUARRY

### LOCATION AND OWNERSHIP

This quarry, located 5 km southwest of Smiths Falls in Pt. Lot 10, Concession 3, South Elmsley Township, United Counties of Leeds and Grenville, has been inter-

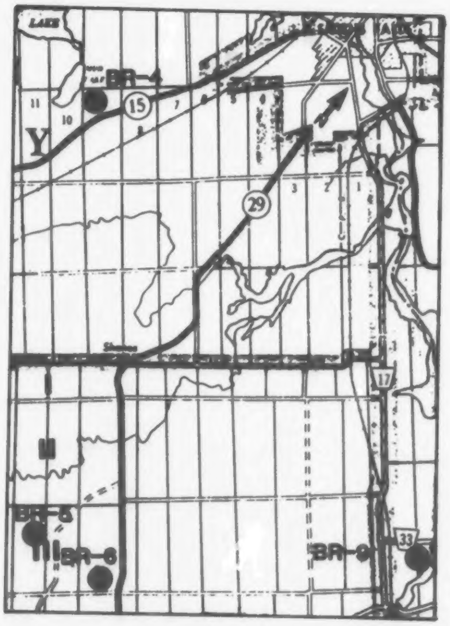


**Figure BR–4–1. LOCATION MAP FOR SHIRLEY QUARRY.**

mittently operated by O. Shirley and Sons (Figure BR-4-1). The quarry licence covers an area of 13.6 ha.

### GEOLOGY

The 11.0 m deep quarry exposes dolostone, commonly very sandy, of the March Formation. The grey-brown, medium-bedded, fine-crystalline dolostones commonly contain medium- to coarse-grained, well-rounded quartz grains. A minor fault zone trends northwest-southeast through the quarry with a 2 m wide breccia zone and associated calcite veins. Displacement of the strata across the fault is less than 1 m. Glacial overburden is about 1 m thick around the quarry.

### Geological Section

| | | *Thickness* |
|---|---|---|
| *UNIT 1* | *March Formation* | *11.0m* |

Dolostone, with interbeds of sandy dolostone and calcareous sandstone: grey-brown to light grey, weathers light brown to grey-brown; medium- to coarse-grained quartz in fine-crystalline dolostone; medium bedded (10-30 cm), with sharp and planar contacts; calcite-filled vugs common in some beds.

| | |
|---|---|
| *Total thickness* | *11.0m* |

### REFERENCES

Goudge, 1938, p. 120

Rogers, 1980, p. 68-69

Williams, in prep., Appendix 1 - Section LQ PE-1

### MAPS

Williams and Wolf, 1984b, OGS Map P.2724

## BR-5 G. TACKABERRY AND SONS CONSTRUCTION COMPANY LIMITED — WILLOWS (NEWBLISS) QUARRY

### LOCATION AND OWNERSHIP

The Willows Quarry is located along Highway 29 south of Smiths Falls, in Pt. Lots 14, 15 and 16, Concession 3, Kitley Township, United Counties of Leeds and Grenville (Figure BR-5-1). The quarry is licensed for 40.5 ha and has been excavated over an area of about 2 ha on a single 6.1 m lift. It is operated intermittently by G. Tackaberry and Sons Construction Company Limited. Production is dependent on the demand of local road construction projects.

### GEOLOGY

The 8.0 m deep quarry exposes dolostones of the Oxford Formation. The grey-brown, medium-bedded, fine-crystalline dolostones commonly contain calcite-filled vugs. Glacial overburden around the quarry is usually 1 to 2 m thick.

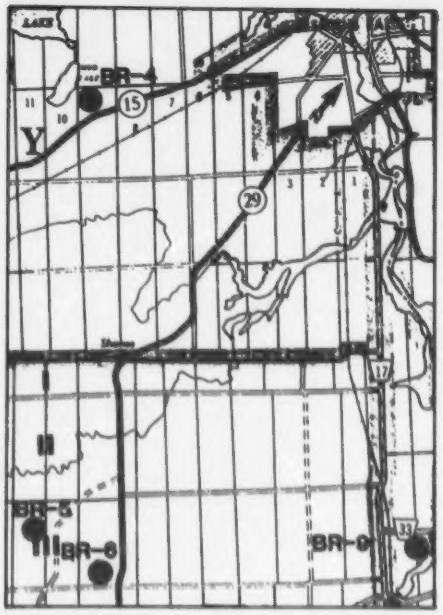


**Figure BR-5-1. LOCATION MAP FOR WILLOWS (NEWBLISS) QUARRY.**

### Geological Section

| | | *Thickness* |
|---|---|---|
| *UNIT 1* | *Oxford Formation* | *8.0m* |

Dolostone: medium grey-brown, weathers light brown to grey-brown; fine crystalline; medium bedded (15-25 cm), with sharp and planar contacts; abundant calcite-filled vugs in some beds.

| | |
|---|---|
| *Total thickness* | *8.0m* |

### REFERENCES

Williams, in prep., Appendix 1 - Section LQ PE-2

### MAPS

Williams and Wolf, 1984b, OGS Map P.2724

## BR-6 G. TACKABERRY AND SONS CONSTRUCTION COMPANY LIMITED — RONAN (LEEDS) QUARRY

### LOCATION AND OWNERSHIP

This quarry, located 1.5 km northwest of the hamlet of Newbliss in Lot 13, Concession 3, Kitley Township, United Counties of Leeds and Grenville, was previously operated by Leeds Asphalt Products (Figure BR-6-1). When visited in 1986 this quarry was licensed to G. Ronan and was inactive. It is now operated intermittently by G. Tackaberry and Sons Construction Company Limited.

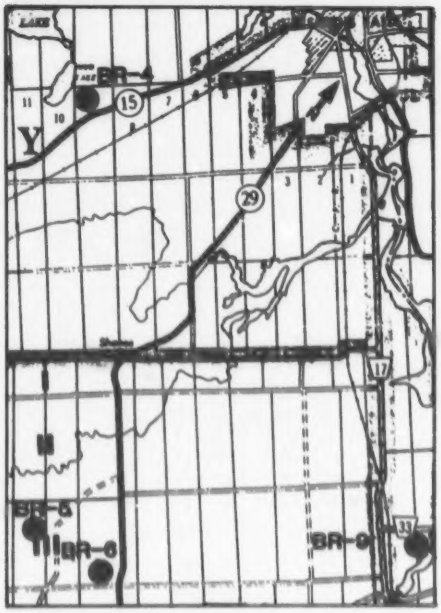


Figure BR-6-1. LOCATION MAP FOR RONAN (LEEDS) QUARRY.

## GEOLOGY

The 10.4 m deep quarry exposes dolostones of the Oxford Formation which are grey–brown, medium bedded, fine to medium crystalline and commonly contain calcite–filled vugs. Glacial overburden around the quarry is generally thin.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 2 Oxford Formation* | *6.0m* |
| Dolostone: light grey, weathers light grey-brown; medium crystalline; medium bedded (15-30 cm); calcite-filled vugs common in some beds; lowermost 20 cm is a thin-bedded dolostone with shale partings; lower contact of unit sharp and planar. | |
| *UNIT 1 Oxford Formation* | *4.4m* |
| Dolostone: medium grey, weathers same; fine crystalline; very thin to thick bedded (2-50 cm); 3.2 m above the base of unit is a 20 cm thick interval of thin-bedded dolostone with shale partings. | |
| *Total thickness* | *10.4m* |

## REFERENCES

Carson, 1982f, OGS OFR 5385 Section B–1

Williams, in prep., Appendix 1 – Section LQ ME–2

## MAPS

Carson, 1982e, OGS Map P.2494

## BR–7 G. TACKABERRY AND SONS CONSTRUCTION COMPANY LIMITED — MERCIER (FRANKVILLE) QUARRY

### LOCATION AND OWNERSHIP

The Mercier Quarry is located 0.5 km northwest of Frankville on Highway 29, in Pt. Lots 19 and 20, Concession 8, Kitley Township, United Counties of Leeds and Grenville (Figure BR–7–1). The property, operated intermittently by G. Tackaberry and Sons Construction Company Limited, is licensed for 32.6 ha.

### GEOLOGY

The 4.5 m deep quarry exposes fine– to medium–crystalline dolostones, interbedded with quartz–rich sandstones of the March Formation. Glacial overburden around the quarry is generally thin.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 1 March Formation* | *4.5m* |
| Dolostone, with interbeds of sandstone: light to medium grey-brown, weathers buff; fine to medium crystalline; thin to thick bedded; calcite-filled vugs present in some dolostone beds; stromatolites present in dolostone beds. | |
| *Total thickness* | *4.5m* |

### REFERENCES

Williams, in prep., Appendix 1 – Section LQ BR–6

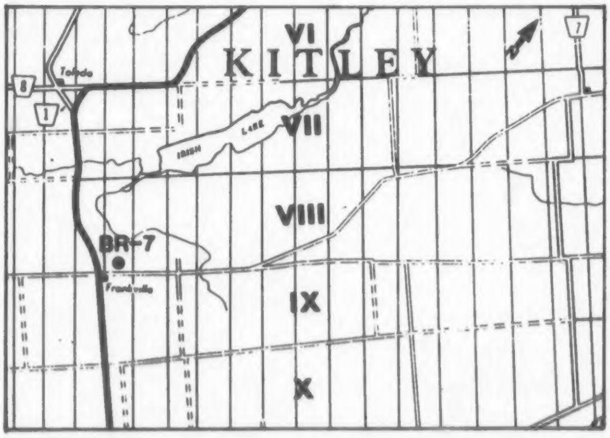


Figure BR-7-1. LOCATION MAP FOR MERCIER (FRANKVILLE) QUARRY.

## BR-8 G. TACKABERRY AND SONS CONSTRUCTION COMPANY LIMITED — LAWSON (ATHENS NO. 2) QUARRY

### LOCATION AND OWNERSHIP

The Lawson Quarry is located 3.5 km northwest of Athens, in Lots 15 and 16, Concession 10, Rear of Yonge & Escott Township, United Counties of Leeds and Grenville (Figure BR-8-1). The quarry is owned and operated by G. Tackaberry and Sons Construction Company Limited and was purchased from the Brundige Construction Company in 1979. The Lawson Quarry has a licensed area of 39 ha.

### GEOLOGY

The 12.45 m deep quarry exposes dolostones, sandy dolostones, and sandstones of the March Formation (Figure BR-8-2). The dolostones range from fine to medium crystalline and are thin to medium bedded. The sandy dolostones are similar except for the presence of medium- to coarse-grained quartz. The sandstones consist of fine- to coarse-grained, well-rounded, well-sorted, quartz arenite. Glacial overburden is generally about 1 m thick around the quarry.

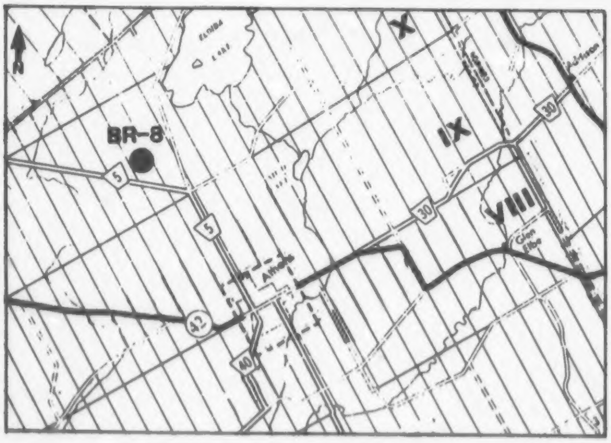

BR-8
X
IX
VIII
5
30
42
40
Athens

Figure BR-8-1. LOCATION MAP FOR LAWSON (ATHENS NO. 2) QUARRY.

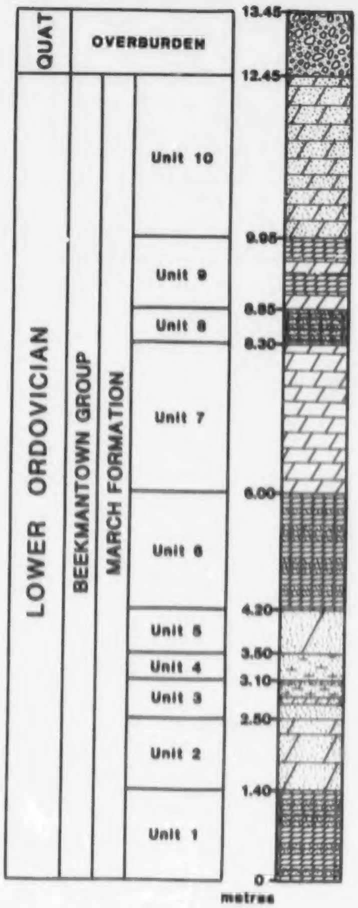

QUAT
OVERBURDEN
LOWER ORDOVICIAN
BEEKMANTOWN GROUP
MARCH FORMATION
Unit 10
Unit 9
Unit 8
Unit 7
Unit 6
Unit 5
Unit 4
Unit 3
Unit 2
Unit 1
13.45
12.45
9.95
8.85
8.30
6.00
4.20
3.50
3.10
2.50
1.40
0
metres

Figure BR-8-2. STRATIGRAPHIC COLUMN FOR LAWSON (ATHENS NO. 2) QUARRY.

### Geological Section

*Thickness*

*UNIT 10 March Formation* *2.5m*

Dolostone: grey-brown with light green stains, weathers light grey; fine crystalline with minor amounts of fine- to coarse-grained quartz; medium bedded (10-20 cm); light green due to thin shale partings which contain glauconite; lower contact of unit sharp and planar.

*UNIT 9 March Formation* *1.1m*

Dolostone: light grey-brown, weathers light brown; fine to medium crystalline; thin to medium bedded (8-12 cm); small calcite-filled vugs common, some with small pyrite crystals; lower contact of unit sharp and planar.

*UNIT 8 March Formation* *0.55m*

Dolostone, with shale partings: light grey-brown, weathers light grey; medium crystalline with medium- to coarse-grained quartz; very thin to thin bedded (2-10 cm) with thin (2 cm) interbeds of shale; small calcite-filled vugs present; lower contact of unit sharp and planar.

*UNIT 7 March Formation* *2.3m*

Dolostone: light grey-brown, weathers light grey; medium crystalline; medium bedded (10-15 cm); top of lower lift at base of unit; lower contact of unit sharp, planar to irregular, probably erosional.

*UNIT 6 March Formation* *1.8m*

Interbedded sandy dolostone and dolostone, with beds interlaminated: Medium grey, weathers grey-brown to brown; very fine- to fine-crystalline dolostone, medium- to very coarse- crystalline sandy dolostone; very thin to thin bedded (3-10 cm), sharp and planar contacts; calcite-filled vugs (3-8 cm in diameter) and isolated patches of calcite crystals; scattered pyrite crystals (1-3 mm); scattered glauconite in sandy dolostone and on bedding planes; rare stromatolites in dolostones; lower contact of unit sharp and irregular, probably erosional.

*UNIT 5 March Formation* *0.7m*

Sandy dolostone: grey-brown, weathers medium grey; dolostones are fine crystalline, sand is coarse grained; one bed; calcite patches are common (2-5 cm), usually white, green, and pink in colour; pyrite crystals are common (1-3 mm); lower contact of unit gradational and burrowed.

*UNIT 4 March Formation* *0.4m*

Calcareous sandstone: white, weathers cream to white; coarse to very coarse grained; one bed; small calcite patches common; some glauconite at top of unit; this bed acts as a good marker within the lower lift; lower contact of unit sharp and irregular, probably erosional.

*UNIT 3 March Formation* *0.6m*

Interlaminated dolostones, dolomitic sandstones, and sandstones: dark grey, weathers medium grey-brown; very fine-crystalline dolostones, medium- grained sandstones; thin bedded (3-5 cm), sharp and planar contacts; calcite patches present, (1-3 cm in size) especially in sandy dolostones; lower contact of unit sharp and planar.

*UNIT 2 March Formation* *1.1m*

Sandy dolostone: light grey-brown, weathers grey-brown; very fine crystalline, with medium-grained quartz grains; thick bedded (50-60 cm), sharp and slightly irregular contacts; abundant calcite patches and calcite-filled vugs are present (2-8 cm in size); some pyrite crystals are present (up to 0.5 cm in size); lower contact of unit sharp and slightly irregular.

*UNIT 1 March Formation* *1.4m*

Sandy dolostone, interbedded with dolostone: medium dark grey, weathers medium grey; fine-crystalline dolostones, with medium- to coarse-grained quartz grains; very thin to thin bedded (2-8 cm), contacts are sharp and planar, with rare very thin shale or shaly dolostone partings; some white calcite patches (2-5 cm in size); most of unit is covered by talus.

*Total thickness* *12.45m*

## QUARRY OPERATION

The quarry is currently excavated on two 6.1 m lifts. Drilling and blasting is contracted. The stone is very hard and requires a tight drill pattern of 2.1 m x 2.1 m with 7.6 cm diameter blast holes.

## PROCESSING

Primary treatment of the blasted rock is performed by a Cedarapids 25 in. x 40 in. jaw crusher, followed by a Cedarapids 855 Commander crusher for secondary treatment. Product sizing is performed with a 5 ft. x 16 ft. Pioneer screening plant.

## PRODUCTS

Shot Rock
Gabion Stone
5/8 in. Crushed Rock
Granular "A", "B" and "C"
1 1/2 in. Clear
7/8 in. Clear
Screenings
HL Products

**Photo BR-8-1.
PRIMARY AND SECONDARY CRUSHING AND SCREENING FACILITIES AT THE LAWSON (ATHENS NO. 2) QUARRY (LOOKING NORTH).**

## COMPANY EQUIPMENT LISTINGS

### Loaders

(2) Cat 977–L (3 yd.)
(2) Cat 988 (7 yd.)
(3) Cat 980 (5 yd.)
(2) Terex 7261–B (6.5 yd.)
(5) Terex 7251–B (4.5 yd.)
(2) Terex 7251–A (3 yd.)
(1) Terex 7271 (7 yd.)
(2) Cat 966D (4 yd.)

### Bulldozers

(2) Cat D6
(1) Cat D7
(1) Cat D3
(1) Terex 7240

### Backhoe

(2) Cat 225 (1.5 yd.)
(1) Cat 215 (1 yd.)
(1) Cat 235 (1 7/8 yd.)

### Crushing Equipment

22 in. x 48 in. and 22 in. x 36 in. and 24 in. x 38 in. Cedarapids Jaw crushers
855 and 555 Cedarapids Commander crushers
Pioneer 5 ft. x 16 ft. Screening Plant
Parker Screening Plant
Power Screen
51 in. Hewitt–Robins cone crusher

The company also owns a fleet of trailer dump (14), belly dump (11), tandem and rock trucks.

### REFERENCES

Hewitt, 1964a, p. 22
Hewitt and Vos, 1972, p. 8–9
Rogers, 1980, p. 56–57
Carson, 1982f, OFR 5385 – Section A–7
Williams, in prep., Appendix 1 – Section LO BR–1

### MAPS

Carson, 1982b, OGS Map P.2495

## BR-9 G. TACKABERRY AND SONS CONSTRUCTION COMPANY LIMITED — JASPER QUARRY

### LOCATION AND OWNERSHIP

The Jasper Quarry is licensed for 16.4 ha and is located 1 km north of Jasper, in Lots 29 and 30, Concession 1, Wolford Township, United Counties of Leeds and Grenville (Figure BR–9–1). The quarry was first opened in 1940 and is now owned and operated by G. Tackaberry and Sons Construction Company Limited. The property was purchased in 1982 from Brundige Construction Co.

### GEOLOGY

The 11.0 m deep quarry exposes fine–crystalline, medium–bedded dolostones of the Oxford Formation in two lifts. Glacial overburden around the quarry is generally thin.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 2 Oxford Formation* | *5.0m* |
| Dolostone: dark grey, weathers same; fine crystalline; medium bedded (10–15 cm), with sharp and planar contacts; calcite–filled vugs abundant; top of lower lift at base of unit; lower contact of unit sharp and planar. | |
| *UNIT 1 Oxford Formation* | *6.0m* |
| Dolostone: medium to dark grey, weathers light grey; fine crystalline; medium bedded (25–30 cm, rarely 15 cm), with sharp, planar contacts and rare, very thin shale partings; scattered small calcite patches present; some beds have fine laminae. | |
| *Total thickness* | *11.0m* |

### QUARRY OPERATION

The first lift of approximately 6.1 m has been completed and stone is now extracted from a second lift of approximately 6.7 m. Drilling and blasting is by contract, on a 2.1 m x 2.1 m drill pattern with 7.6 cm diameter holes.

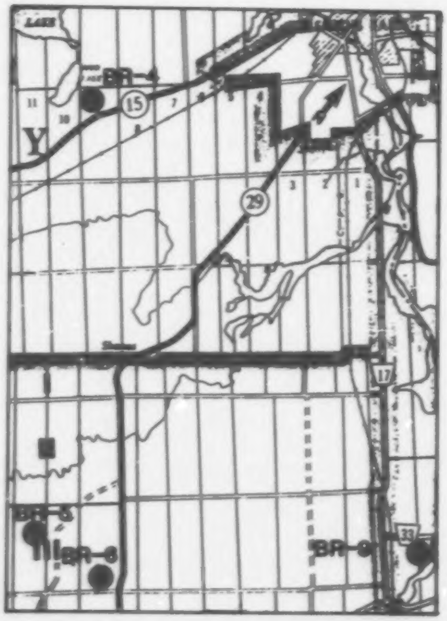


**Figure BR–9–1. LOCATION MAP FOR JASPER QUARRY.**

**Photo BR-9-1. LOADING BLAST HOLES AT THE JASPER QUARRY (LOOKING WEST).**

## PROCESSING

Crushing and screening is performed by a portable system assembled onsite as required.

## PRODUCTS

Gabion Stone
Shot Rock
Granular "A", "B", and "C"
1 1/2 in. Clear
7/8 in. Clear
Screenings
HL Stone
Concrete Stone

## REFERENCES

Hewitt, 1964a, p. 19–20
Hewitt and Vos, 1972, p. 10
Rogers, 1980, p. 57
Williams, in prep., Appendix 1 – Section LQ ME–1

## MAPS

Carson, 1982e, OGS Map P.2494

# BR–10 WILLIAM CLOW — SHERWOOD SPRINGS QUARRY

## LOCATION AND OWNERSHIP

This quarry is located at the eastern junction of Highway 401 and the Thousand Islands Parkway, 1 km south of the hamlet of Sherwood Springs in Pt. Lots 2–3, Concession 1, Front of Yonge Township, United Counties of Leeds and Grenville (Figure BR–10–1). It was once used as a source for aggregate for asphalt laid down on the nearby Highway 401. The quarry also has been intermittently operated by W. Clow for crushed stone. The property is licensed for 70.9 ha.

## GEOLOGY

The 4.5 m of strata exposed above the water level in the partially flooded quarry consist of sandy dolostones and sandstones of the March Formation. A recent excavation east of the main quarry above the water level is described below. Glacial overburden around the quarry is generally less than 2 m thick.

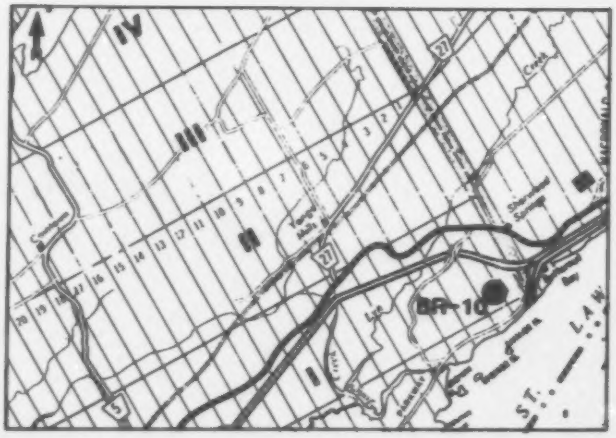


**Figure BR-10-1. LOCATION MAP FOR SHERWOOD SPRINGS QUARRY.**

### Geological Section

| | Thickness |
|---|---|
| *UNIT 3 March Formation* | *1.5m* |
| Dolostone: blue-grey to medium grey, weathers same; fine crystalline with medium- to coarse-grained quartz common; thin to medium bedded; calcitic patches common; lower contact of unit sharp. | |
| *UNIT 2 March Formation* | *1.5m* |
| Sandstone: white to light brown, weathers light brown; medium grained; thin bedded; well sorted, subrounded, non-calcareous; lower contact sharp and slightly irregular. | |
| *UNIT 1 March Formation* | *1.5m* |
| Dolostone: blue-grey to medium grey, weathers same; fine crystalline with medium- to coarse- grained quartz common; thin to medium bedded; calcitic patches common. | |
| *Total thickness* | *4.5m* |

### REFERENCES

Rogers, 1980, p. 54–55

Williams, in prep., Appendix 1 – Section LQ BR–5

### MAPS

None

## BR–11 G. TACKABERRY AND SONS CONSTRUCTION COMPANY LIMITED – WOODS (TINCAP) QUARRY

### LOCATION AND OWNERSHIP

The Woods Quarry was licensed and opened in 1985 by the owner and operator, G. Tackaberry and Sons Construction Company Limited (Figure BR–11– 1). The property is licensed for 21 ha and is located 2.5 km west of Tincap in part Lot 20, Concession 5, Elizabethtown Township, United Counties of Leeds and Grenville.

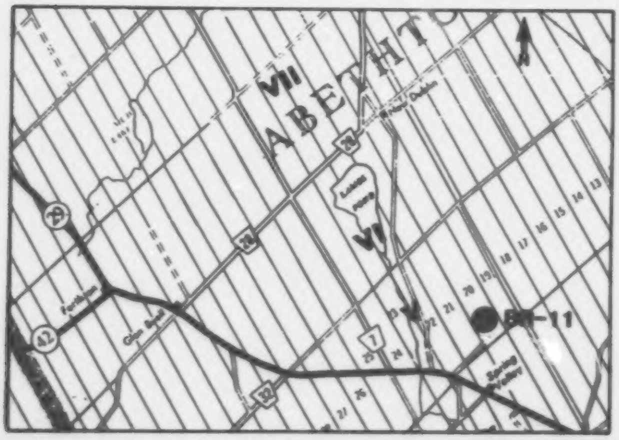


Figure BR–11–1. LOCATION MAP FOR WOODS (TINCAP) QUARRY.

Photo BR–11–1. BLOWING OUT RAIN WATER IN BLAST HOLES BEFORE LOADING WITH EXPLOSIVES AT WOODS (TINCAP) QUARRY (LOOKING NORTH).

### GEOLOGY

The 10.1 m thick quarry face exposes fine– to medium–crystalline dolostones of the Oxford Formation. Glacial overburden around the quarry is thin, varying from a trace to 30 cm in thickness.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 1 Oxford Formation* | *6.0m* |
| Dolostone: grey-brown to medium grey, weathers light grey-brown; fine to medium crystalline; medium bedded; calcite-filled vugs present in some beds. | |
| *Total thickness* | *6.0m* |

### QUARRY OPERATION

The quarry is opened over approximately 2 ha on a single lift of 6 m. Drilling and blasting is contracted. Crushing and screening is performed by a portable system.

### PRODUCTS

Granular "A" and "B"

### REFERENCES

None

### MAPS

None

## BR-12 PERMANENT CONCRETE – BROCKVILLE QUARRY

### LOCATION AND OWNERSHIP

The large Brockville Quarry is located on the north side of Highway 2, on the eastern outskirts of the City of Brockville, in Part Lots 3, 4, 5, Concession 1, Elizabethtown Township, United Counties of Leeds and Grenville (Figure BR-12- 1). The property is licensed for 77 ha and is owned and operated by Permanent Concrete, a division of Lafarge Canada Inc.

### GEOLOGY

The 21.0 m deep quarry exposes sandy dolostones and dolostones of the March Formation which are overlain by dolostones of the Oxford Formation (Figure BR-12-2). The contact between the two formations is exposed just below the top of the lowest lift. Glacial overburden around the quarry is about 3 to 5 m thick over the irregular bedrock surface.

#### Geological Section

| | Thickness |
|---|---|
| *UNIT 2 Oxford Formation* | *14.5m* |

Dolostone: light grey to light grey-brown, weathers grey-brown to medium brown; fine crystalline; dominantly medium bedded (10-30 cm) with some thinner (5-10 cm) beds, with sharp, planar contacts, some with dark grey shale partings; rare, very thin, sandy dolostone intervals at base of unit; calcite-filled vugs are common, especially in beds with abundant stromatolites; top of lower lift 0.3 m above base of unit; lower contact of unit sharp and slightly irregular.

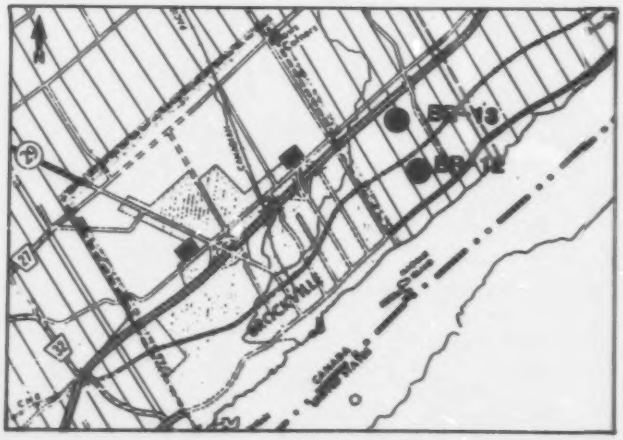


Figure BR-12-1. LOCATION MAP FOR BROCKVILLE QUARRY.

| | |
|---|---|
| *UNIT 1 March Formation* | *6.5m* |

Sandy dolostone, with interbeds of dolostones, calcareous and non-calcareous sandstones: light grey-brown to medium grey-white and light brown, weathers light grey to light grey-brown to light brown; fine-crystalline dolostones, medium- to coarse-grained sandy dolostones; medium bedded (20-30 cm), sharp contacts with very rare, very thin shale partings; some sandy dolostone beds have rare, large calcite-filled vugs; uppermost bed of formation is a thick, white sandstone just below the top of the bottom lift.

| | |
|---|---|
| *Total thickness* | *21.0m* |

### QUARRY OPERATION

The quarry is operated on three lifts of 6 m, 8.5 m and 6.5 m. The third lift is in a very hard dolomitic sandstone and is excavated solely to produce HL3 modified stone, a top quality skid-resistant aggregate used on highways with high volume traffic, and currently produced in a limited number of quarries in southern Ontario. Drilling and blasting is contracted; a drill pattern of 2.4 m x 2.1 m is used on the first and second lifts and a pattern of 2.1 m x 2.1 m is used on the third (bottom) lift, with 6.4 cm diameter blast holes.

### PROCESSING

Two loaders, a Terex 9 yd. and a Cat 980 6 yd., are used to haul the blasted stone approximately 120 m to a Hewitt-Robins 30 in. x 48 in. primary jaw crusher. The crushed stone is conveyed approximately 60 m to a Hewitt-Robins screening plant. Oversize material is sent

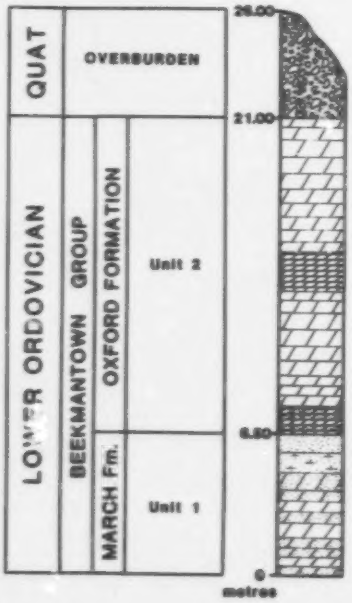


Figure BR-12-2. STRATIGRAPHIC COLUMN FOR BROCKVILLE QUARRY.

to two Symons 4 1/4 ft. cone crushers for secondary treatment, the product then being rescreened.

Permanent Concrete has a quality control laboratory and technician at the Brockville Quarry to ensure that product specifications are met at both the Brockville and Cornwall quarry operations.

### PRODUCTS

Armour Stone
Gabion Stone 3 in. to 6 in.
Granular "A", "B" and "C"
Septic 1 1/4 in. Clear
3/4 in. Concrete Stone
3/8 in. Chips
1/4 in. Dust
HL3 Modified

### REFERENCES

Goudge, 1938, p. 122–123
Hewitt, 1960, p. 19–20
Hewitt, 1964a, p. 24–25
Hewitt and Vos, 1972, p. 11–12
Rogers, 1980, p. 61–62
Williams, in prep., Appendix 1 – Section LQ BR-3

### MAPS

Carson, 1982b, OGS Map P.2495

## BR-13 WARREN PAVING AND MATERIALS GROUP LIMITED — BROCKVILLE QUARRY

### LOCATION AND OWNERSHIP

This quarry, located 3 km northeast of Brockville, just south of Highway 401, in Lots 3-4, Concession 1, Elizabethtown Township, United Counties of Leeds and Grenville, has been operated by Dibblee Construction Company Limited, a division of the Warren Paving and Materials Group Ltd. (Figure BR-13-1). The property is licensed for 37.7 ha.

### GEOLOGY

The quarry was partially filled with water at the time of the field work. Above the water level 5.6 m of Oxford Formation dolostone was exposed. The dolostones are light grey, fine crystalline and are medium bedded (20–30 cm); some of the beds contain minor amounts of medium- to coarse-grained quartz grains. These beds are very similar to those exposed in the upper part of the Brockville Quarry of Permanent Concrete (BR-12) which is located 1 km to the south of this quarry. Glacial overburden around the quarry is generally less than 2 m thick.

### REFERENCES

Rogers, 1980, p. 63–64

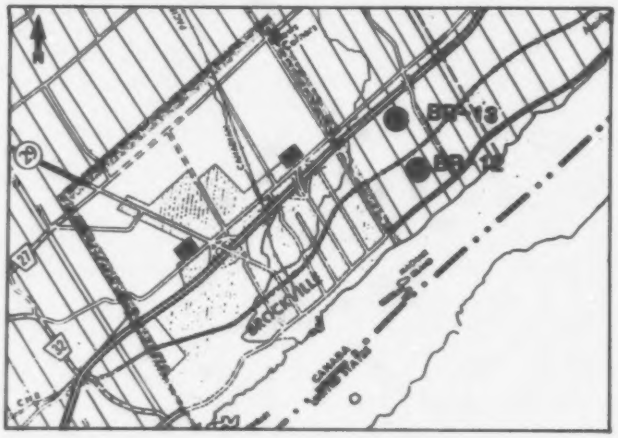


Figure BR-13-1. LOCATION MAP FOR BROCKVILLE (WARREN) QUARRY.

Williams, in prep., Appendix 1 – Section LQ BR-4

### MAPS

Carson, 1982b, OGS Map P.2495

## BR-14 G. TACKABERRY AND SONS CONSTRUCTION COMPANY LIMITED — WINGS (MAITLAND) QUARRY

### LOCATION AND OWNERSHIP

The Wings Quarry is located 6 km north of Maitland in part Lots 24, 25 and 26, Concession 3, Augusta Township, United Counties of Leeds and Grenville (Figure

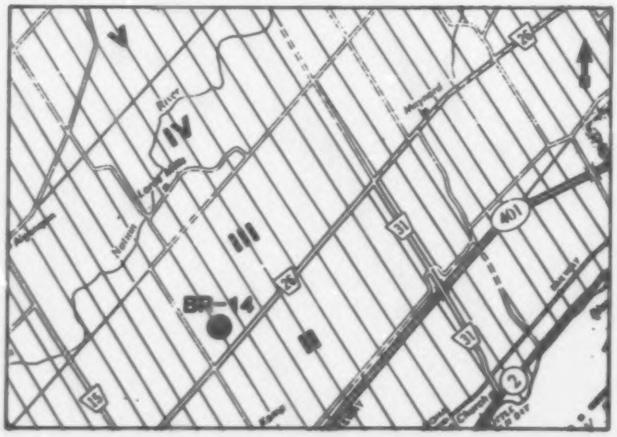


Figure BR-14-1. LOCATION MAP FOR WINGS (MAITLAND) QUARRY.

BR-14-1). The quarry is owned and operated intermittently by G. Tackaberry and Sons Construction Company Limited. The quarry was acquired in 1982 and is licensed for 15.1 ha. In 1980 aggregate was supplied from this quarry for the repaving of Highway 401 from Maitland to Prescott.

### GEOLOGY

The 6.0 m deep quarry exposes fine- to medium-crystalline, medium-bedded dolostones of the Oxford Formation. Glacial overburden around the quarry is less than 1 m thick.

### Geological Section

| | *Thickness* |
|---|---|
| *UNIT 1 Oxford Formation* | *6.0m* |
| Dolostone: medium brown to grey, weathers brown; fine to medium crystalline; medium bedded; minor amount of fine-grained quartz sand is also present in some beds. | |
| *Total thickness* | *6.0m* |

### QUARRY OPERATION

The quarry has been excavated to a depth of 6.0 m over an area of about 4 ha. Drilling and blasting is contracted. Crushing and screening is performed by a portable system.

### PRODUCTS

Granular "A" and "B"

### REFERENCES

Hewitt, 1964a, p. 25-26
Hewitt and Vos, 1972, p. 8-9
Rogers, 1980, p. 57
Williams, in prep., Appendix 1 - Section LQ BR-2

### MAPS

Carson, 1982b, OGS Map P.2495

## BR-15 MAPLE GROVE (KEMPTVILLE) LTD. — KEMPTVILLE QUARRY

### LOCATION AND OWNERSHIP

This recently opened quarry, located 3 km east of Kemptville in Lot 10, Concession 6, South Gower Township, United Counties of Leeds and Grenville, is operated intermittently by Maple Grove (Kemptville) Limited (Figure BR-15-1). The property is licensed for 12.0 ha.

### GEOLOGY

The 7.0 m deep quarry exposes fine-crystalline, thin- to medium-bedded dolostones of the Oxford Formation. Small calcite-filled vugs are common throughout the quarry. Glacial overburden is between 1 and 2 m thick.

### Geological Section

| | *Thickness* |
|---|---|
| *UNIT 1 Oxford Formation* | *7.0m* |
| Dolostone: dark grey, weathers grey-brown; very fine to fine crystalline; thin to medium bedded (5-15 cm), sharp contacts, with some very thin, dark grey shale partings; calcite- filled vugs and patches are very common in some beds, both white and pink calcite present; stromatolites rarely present; some beds faintly laminated. | |
| *Total thickness* | *7.0m* |

### REFERENCES

None

### MAPS

None

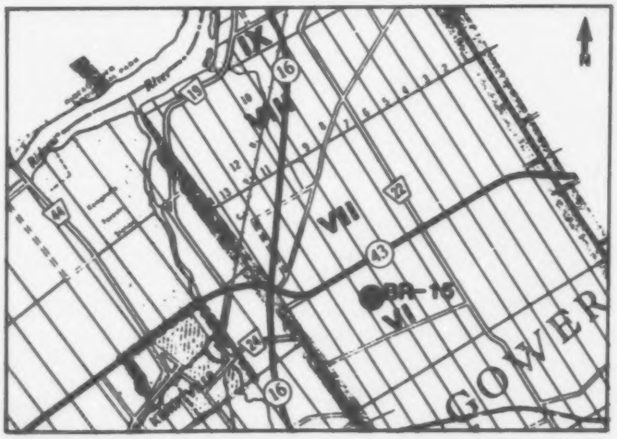


Figure BR-15-1. LOCATION MAP FOR KEMPTVILLE QUARRY.

# Napanee District

## INTRODUCTION

Napanee District is the westernmost district in the Eastern Region of southern Ontario, adjoining Brockville District on the east, Tweed District on the north, Lindsay District on the west and Lake Ontario to the south.

Three hundred and sixteen quarries in the Napanee District are documented in the quarry inventory (Appendix IV, Volume I); twenty–two are currently active, fifteen report intermittent production with the balance representing past producing quarries of geological significance.

All of the active and intermittently active quarries were visited during the study and include the following:

| | |
|---|---|
| *NP–1* | *St. Lawrence Cement Company Inc. – Ogden Point Quarry, Colborne (active)* |
| *NP–2* | *Trenton Gravel Products Ltd. – Consecon Quarry (intermittent)* |
| *NP–3* | *H.J. McFarland Construction Co. – Mountain View Quarry (intermittent)* |
| *NP–4* | *Harvey Putnam – Cannifton Quarry (active)* |
| *NP–5* | *H.J. McFarland Construction Co. – Point Anne (Belleville) Quarry (active)* |
| *NP–6* | *H.J. McFarland Construction Co. – Long Quarry (intermittent)* |
| *NP–7* | *Lake Ontario Cement Ltd. – Picton Quarry (active)* |
| *NP–8* | *Miller Paving Limited – Prince Edward (Picton) Quarry (active)* |
| *NP–9* | *Trenton Gravel Products Ltd. – Napanee Quarry (active)* |
| *NP–10* | *H.J. McFarland Construction Co. – Roblindale Quarry (intermittent)* |
| *NP–11* | *Custom Mobile Concrete – Selby Quarry (active)* |
| *NP–12* | *J.R. Storey Construction Ltd. – Napanee Quarry (active)* |
| *NP–13* | *J.C. Dennison – Napanee Quarry (intermittent)* |
| *NP–14* | *Griffin Brothers (Gananoque) Ltd. – Dillon Quarry (active)* |
| *NP–15* | *Township of Camden East – Camden East Quarry (intermittent)* |
| *NP–16* | *J.R. Storey Construction Ltd. – Morven Quarry (intermittent)* |
| *NP–17* | *J.C. Denison – Storms Corners Quarry (active)* |
| *NP–18* | *Lafarge Canada Inc. – Bath Quarry and Plant (active)* |
| *NP–19* | *F.G. Bezanson and Son Ltd. – Wilton Quarry (active)* |
| *NP–20* | *Township of Amherst Island – Amherst Island (Caughey) Quarry (intermittent)* |
| *NP–21* | *Portland Township (Hartington) Quarry (intermittent)* |
| *NP–22* | *W.J. McKendry and Sons Limited – Westbrook Quarry (active)* |
| *NP–23* | *Wood's Sand and Gravel Ltd. – Collins Bay Quarry (active)* |
| *NP–24* | *H.J. McFarland Construction Company – Kingston Quarry (intermittent)* |
| *NP–25* | *Township of Kingston – Kingston Quarry (intermittent)* |
| *NP–26* | *W.J. McKendry and Sons Ltd. – Cranston (Kepler) Quarry (active)* |
| *NP–27* | *Frontenac Aggregates and Construction – Elginburg Quarry (active)* |
| *NP–28* | *Spaffordton Quarry (intermittent)* |
| *NP–29* | *W.J. McKendry and Sons Limited – Glenburnie (Kingston) Quarry (active)* |
| *NP–30* | *Wood's Sand and Gravel Limited – Macadoos Lane (Glen Lawrence) Quarry (active)* |
| *NP–31* | *H.J. McFarland Construction Company – Macadoos Lane (Bilow) Quarry (intermittent)* |
| *NP–32* | *Frontenac Aggregates and Construction – Pittsburgh Quarry (active)* |
| *NP–33* | *Mill Point Quarry (intermittent)* |
| *NP–34* | *Griffin Brothers (Gananoque) Ltd. – Battersea Quarry (active)* |
| *NP–35* | *Griffin Brothers (Gananoque) Ltd. – Joyceville Quarry (active)* |
| *NP–36* | *Howe Island Quarry (intermittent)* |
| *NP–37* | *Warren Paving and Materials Group Limited – Westbrook Quarry (active)* |

## REGIONAL GEOLOGY

Napanee District extends southward from a line 60 km north of and parallel to Lake Ontario's northern shoreline (Figure NP–0–1). The study area encompasses all, or parts of, Northumberland, Hastings, Lennox and Addington, Frontenac, and Prince Edward Counties.

Most of Napanee District is underlain by rocks of Paleozoic age with some Precambrian rocks present in the northern part of the district. The Paleozoic– Precambrian contact approximately follows the northern boundary of the Napanee District. This contact is delineated in scattered areas by a northward–facing escarpment, such as in the Tweed area and north of Kingston. Elsewhere

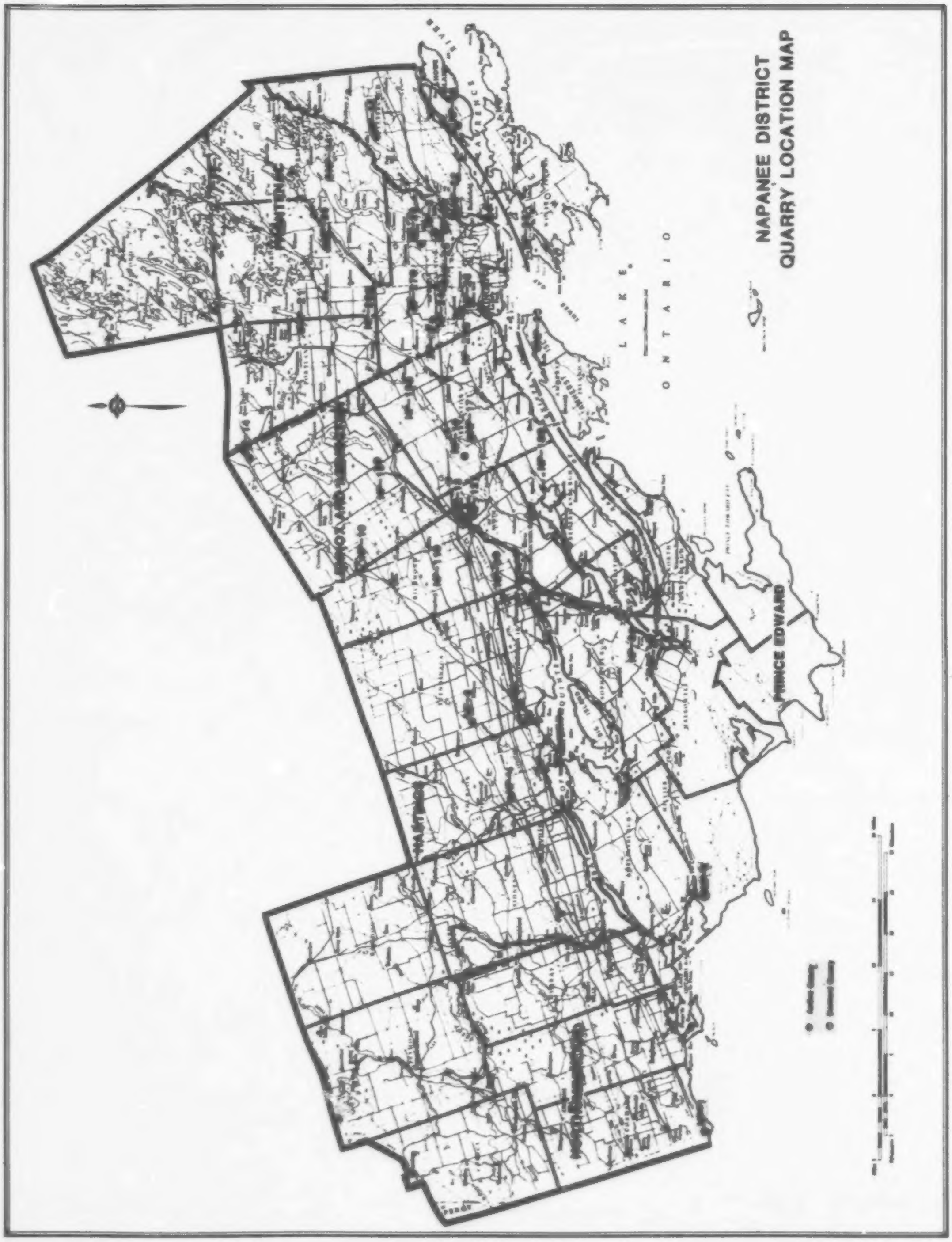

NAPANEE DISTRICT
QUARRY LOCATION MAP
LAKE
ONTARIO
PRINCE EDWARD
ST. LAWRENCE
RIVER

Figure NP-0-1. NAPANEE DISTRIST QUARRY LOCATION MAP.

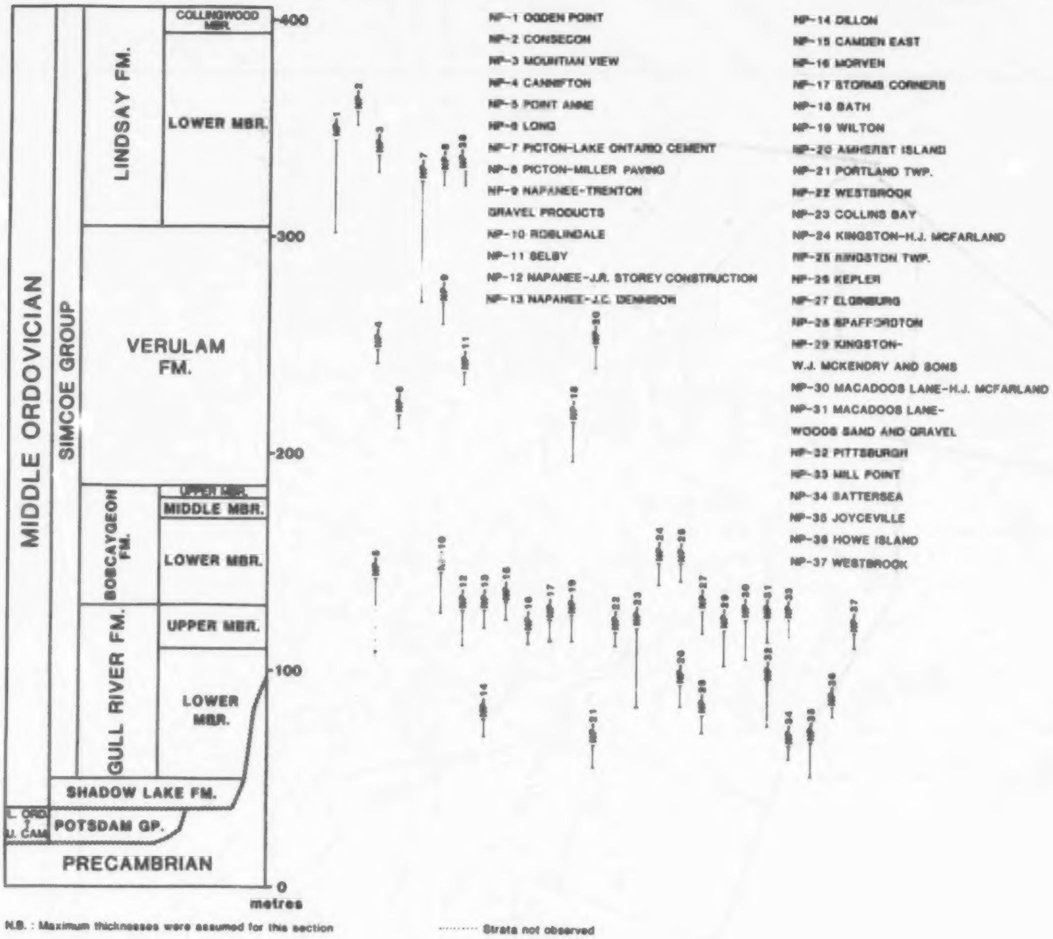

MIDDLE ORDOVICIAN
SIMCOE GROUP
LINDSAY FM.
COLLINGWOOD MBR.
LOWER MBR.
VERULAM FM.
BOBCAYGEON FM.
UPPER MBR.
MIDDLE MBR.
LOWER MBR.
GULL RIVER FM.
UPPER MBR.
LOWER MBR.
SHADOW LAKE FM.
L. ORD. ? U. CAM.
POTSDAM GP.
PRECAMBRIAN
400
300
200
100
0
metres
NP-1 OGDEN POINT
NP-2 CONSECON
NP-3 MOUNTIAN VIEW
NP-4 CANNIFTON
NP-5 POINT ANNE
NP-6 LONG
NP-7 PICTON-LAKE ONTARIO CEMENT
NP-8 PICTON-MILLER PAVING
NP-9 NAPANEE-TRENTON
GRAVEL PRODUCTS
NP-10 ROBLINDALE
NP-11 SELBY
NP-12 NAPANEE-J.R. STOREY CONSTRUCTION
NP-13 NAPANEE-J.C. DENNISON
NP-14 DILLON
NP-15 CAMDEN EAST
NP-16 MORVEN
NP-17 STORMS CORNERS
NP-18 BATH
NP-19 WILTON
NP-20 AMHERST ISLAND
NP-21 PORTLAND TWP.
NP-22 WESTBROOK
NP-23 COLLINS BAY
NP-24 KINGSTON-H.J. MCFARLAND
NP-25 KINGSTON TWP.
NP-26 KEPLER
NP-27 ELGINBURG
NP-28 SPAFFORDTON
NP-29 KINGSTON-
W.J. MCKENDRY AND SONS
NP-30 MACADOOS LANE-H.J. MCFARLAND
NP-31 MACADOOS LANE-
WOODS SAND AND GRAVEL
NP-32 PITTSBURGH
NP-33 MILL POINT
NP-34 BATTERSEA
NP-35 JOYCEVILLE
NP-36 HOWE ISLAND
NP-37 WESTBROOK
N.B. : Maximum thicknesses were assumed for this section
........ Strata not observed

**Figure NP-0-2.** STRATIGRAPHIC COLUMN SHOWING PRINCIPAL QUARRIES OF NAPANEE DISTRICT.

the contact is covered by glacial debris. Most of the Paleozoic strata are covered with thin glacial deposits, and bedrock exposures are numerous in many areas, especially south of Belleville and eastward to Kingston.

The oldest Paleozoic rocks in the Napanee District include the Cambro–Ordovician sandstones of the Potsdam Group northeast of Kingston, and the sandstones and shales of the Middle Ordovician Shadow Lake Formation (Figure NP–0–2).

The Potsdam Group consists of up to 20 m of arkoses and quartz arenites and is located in a small area north and east of Kingston. Although these rocks were, and still are, a source for building and ornamental stone, these sandstones are not used by the limestone industry.

The Shadow Lake Formation usually consists of a basal conglomerate overlain by arkosic sandstones and shales. It varies in thickness from zero, where it is absent over Precambrian topographic highs, to up to 15 m thick where it fills depressions in the Precambrian surface. None of the quarries in the Napanee District extend down into the Shadow Lake Formation, and there are only small scattered exposures evident.

Overlying the Shadow Lake Formation is the Gull River Formation of the Simcoe Group, which outcrops in a band from Campbellford to Kingston, and has been utilized in numerous quarries, including many abandoned ones.

The Gull River Formation is subdivided into two members, based on work by Williams (in prep.) and the exposure in the Marmora Pit (TW–1) in Tweed District. This differs from the four-fold subdivision proposed by Liberty (1971c) for these strata in the Kingston area. The Gull River Formation (as defined by Williams, in prep.) varies in thickness from 30 to 80 m, increasing in thickness from west to east.

The lower member of the Gull River Formation consists of alternating limestone and dolostone units, 0.5 to 1.5 m thick. The limestones are light to medium grey, thin to medium bedded, and microcrystalline, and the dolostones are light brown to light green, thin to medium bedded, fine crystalline. The lower part of the member includes thin intervals of shale and quartz–rich sandstone. Several of the light green dolostone beds weather distinctively and provide excellent marker horizons. The lower member ranges in thickness from 20 m in the Marmora Pit (TW–1) to about 60 m in the Kingston area. Numerous quarries, including the Collins Bay Quarry of Wood's Sand and Gravel (NP–23) and the Pittsburgh Quarry of Frontenac Aggregates and Construction (NP–32), expose thick intervals of the member. Most operations extract the rock for aggregates.

The upper member of the Gull River Formation consists of thin–bedded, microcrystalline to fine–crystalline limestones which are interbedded with thin, dark grey, usually calcareous, shale partings. The member thickens from 7 m in the Marmora Pit (TW–1) to over 16 m near Napanee (NP–12). Unlike regions to the west, the upper member is utilized as a source of aggregate in the Napanee–Kingston area. Significant exposures of this member are displayed in the Napanee Quarry of J.R. Storey Construction (NP–12), the Wilton Quarry (NP–19), and the Macadoos Lane Quarry of Wood's Sand and Gravel (NP–31).

Overlying the Gull River Formation is the Bobcaygeon Formation which outcrops sporadically in the Napanee District. Most exposures occur between Belleville and Napanee. Of the few quarries that have been excavated into this formation, most expose strata of the lower member.

The Bobcaygeon Formation is subdivided into three members, based primarily on their shale content (Williams, in prep.). The lower and upper members generally have minor amounts of interbedded shale whereas the middle member has more significant amounts. The limestones of the lower member consist of thick to massive beds of microcrystalline limestone and medium– to coarse– grained calcarenites. The limestones of the middle and upper members are thin– to medium–grained calcarenitic limestone. The formation maintains a uniform thickness of 50 to 60 m across the district.

The 40 m thick lower member of the Bobcaygeon Formation is characterized by thick– to massive–bedded (0.5–1.5 m) limestone, often with black chert nodules in many beds. Around Kingston these thick beds easily fracture and weather into thinner layers which can be mistaken for bedding. Quarries which expose a significant amount of this member include the Point Anne Quarry (NP–5), the Roblindale Quarry (NP–10), the Kingston Quarry of H.J. McFarland Construction Company (NP–23), and the Township of Kingston Quarry (NP–25). The rock from these quarries is currently used as a source for crushed stone, although previously the cement manufacturing (Point Anne Quarry; NP–5) industry utilized these limestones.

The middle and upper members of the Bobcaygeon Formation are both about 10 m thick throughout the Napanee District. Only a thin interval of the lowermost section of the middle member is exposed in the Point Anne Quarry (NP–5). The upper member is not exposed in any quarries in this district.

Overlying the Bobcaygeon Formation are the interbedded limestones and shales of the Verulam Formation, which in the Napanee District underlie the area west of Kingston and the Trenton–Belleville area. The rocks of this formation are an important source for the cement manufacturing industry, in addition to being a source of crushed stone.

The Verulam Formation consists of interbedded thin–bedded limestone, shaly limestone, and shale. The very fossiliferous limestones vary from an evenly textured, fine–crystalline limestone to medium– to coarse–grained calcarenites. The upper part of the formation weathers to a distinctive blue–grey colour, different from the usual light to medium grey colour. The formation is up to 120 m thick in the Napanee District.

Outcrops of the Verulam Formation are common along the Lake Ontario shoreline between Kingston and Belleville and across the northern part of Prince Edward County. The quarries in this formation that are utilized by the cement manufacturing industry include the Picton Quarry of Lake Ontario Cement (NP–7) and the Bath Quarry of Lafarge Canada (NP–18). Several quarries west of Napanee and around Belleville use rock from the Verulam Formation as a source of crushed stone.

Overlying the Verulam Formation are the nodular limestones of the Lindsay Formation which underlies the extreme western and southern parts of the Napanee District. These rocks are used both for cement manufacturing and as a source of crushed stone.

The Lindsay Formation is subdivided into two members (Russell and Telford, 1983); the nodular limestone of the lower member, as used in this report, corresponds to the Lindsay Formation as defined by Liberty (1969), and the black shales of the upper, Collingwood Member that have been assigned previously to the lower member of the Whitby Formation as defined by Liberty (1969). Recent subsurface studies of this part of the section (Johnson et al., 1983) suggest the inclusion of these black shales as an upper member of Lindsay Formation because of the highly calcareous nature of the shales and the apparently conformable contact between the two members (Russell and Telford, 1983).

The lower member of the Lindsay Formation has a total thickness greater than 100 m in the southern part of

Prince Edward County. It consists mainly of grey to brown, fine-crystalline, medium- to thick-bedded, nodular limestone. The upper member, referred to as the Collingwood Member, is a calcareous, petroliferous black shale with a rich invertebrate fossil content. The contact between the lower and Collingwood members of the Lindsay Formation also marks the contact between the Middle and Upper Ordovician in Central Ontario. The upper member is not exposed in the Napanee District, but it does occur in the Bowmanville Quarry (L–1), in the Lindsay District to the west.

Extensive outcrops of the lower member of the Lindsay Formation occur in the southern three-quarters of Prince Edward County. Numerous quarries, most now abandoned, were excavated in this area for crushed stone, including the Consecon Quarry (NP–2), the Mountain View Quarry (NP–3), and the Picton Quarry of Miller Paving (NP–8). In addition, rock for the cement manufacturing industry is quarried at the Ogden Point Quarry of St. Lawrence Cement Inc. (NP–1) and the Picton Quarry of Lake Ontario Cement Ltd. (NP–7), both of which expose significant sections of the lower member of the Lindsay Formation.

## LIMESTONE INDUSTRIES

The principal limestone industries in Napanee District are cement and construction aggregates with agricultural lime being produced from several high purity limestone quarries.

Cement production in 1986 for the district including production from the Lake Ontario Cement Picton plant and the Lafarge Canada plant at Bath was reported to be 1,689,000 tonnes (1987 Ontario Mineral Score).

Both plants produce a wide variety of products including, but not restricted to, Normal Portland, High Early Strength Portland, Sulfate Resisting Portland, Low Heat of Hydration Portland and Masonry Cement.

Stone production in 1986 for the district comprising production from Northumberland and Prince Edward Counties and the southern portions of Frontenac, Lennox and Addington and Hastings Counties, was approximately 5,986,000 tonnes (1987 Ontario Mineral Score) and was used by the cement industry for the production of cement and by the construction industry as road, asphalt and construction aggregate.

The largest stone producers include St. Lawrence Cement – Ogden Point Quarry (NP–1), Lake Ontario Cement – Picton Quarry (NP–7) and Lafarge Canada – Bath Quarry (NP–18) which between them quarry approximately 4,860,000 tonnes or about 80% of the stone produced, all of which is internally consumed.

The balance of the production, or about 1,126,000 tonnes, is quarried primarily for use as road building and construction aggregate.

Agricultural lime is produced in the district on a demand basis and includes production from the J. R. Storey Construction Ltd. high purity limestone quarry at Napanee (NP–12) which is trucked to their Morven (NP–16) quarry for crushing and screening.

## NP–1 ST. LAWRENCE CEMENT COMPANY INC. — OGDEN POINT QUARRY

### LOCATION AND OWNERSHIP

St. Lawrence Cement Company Inc. operates a large quarry at Ogden Point in Lots 29–35, Broken Front and Concession 1, Cramahe Township, Northumberland County. The quarry, which began operations in 1959, is located approximately 2 km south of the Village of Colborne on the shore of Lake Ontario (Figure NP–1–1) and has an annual capacity in excess of 2.5 million tonnes. All shipments are by water from a large dock facility to the St. Lawrence Cement plant at Clarkson (Mississauga).

### GEOLOGY

The quarry exposes about 41 m of Middle Ordovician limestone of the Verulam and Lindsay Formations (Figure NP–1–2) and is operated in two lifts of subequal height. The lowest 3.2 m of the lower lift consists of interbedded limestone and shale of the Verulam Formation. The remaining strata in the quarry are thin to medium bedded, usually alternating fine-crystalline and medium-grained calcarenitic limestones of the lower member of the Lindsay Formation. These limestone beds commonly display a nodular texture, in which the nodules are enveloped in thin shale partings. The lower 12.8 m of this formation are thicker bedded than the overlying strata. The Lindsay Formation strikes 030° and dips to the south at less than 1°.

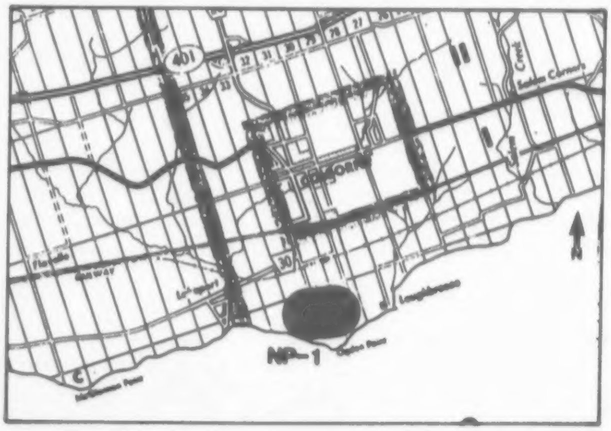


Figure NP-1-1. LOCATION MAP FOR OGDEN POINT QUARRY.

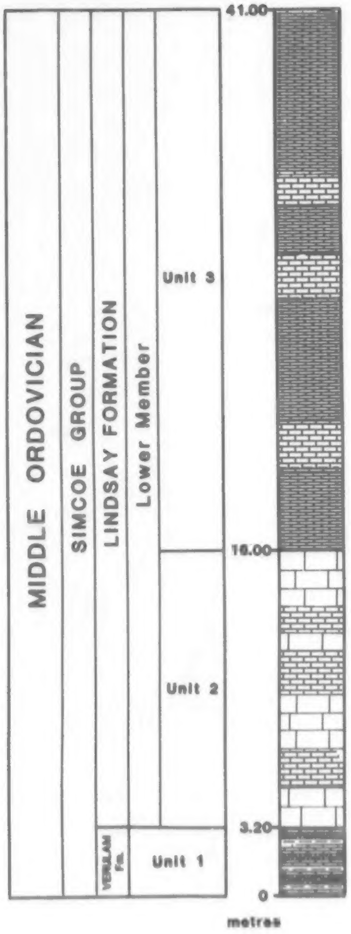


Figure NP-1-2. STRATIGRAPHIC COLUMN FOR OGDEN POINT QUARRY.

Overburden at the quarry site ranges from 0.3 to 1.5 m in thickness.

## Geological Section

| | | Thickness |
|---|---|---|
| *UNIT 3* | *Lindsay Formation, lower member* | *25.0m* |

Limestone: dark grey to grey-brown at top, weathers light grey to light grey-brown at top; alternating beds of very fine- to fine-crystalline limestone with coarse- to very coarse-grained calcarenites and bioclastic limestone; mostly thin bedded (5-10 cm), with some medium bedded (10-30 cm), contacts generally marked by dark grey, thin shale partings; very fossiliferous with brachiopods, crinoidal debris and trilobites commonly present; upper 8 m of unit displays distinct nodular texture, weathering to a rubble in uppermost 2 m; top of lower lift 7.0 m above base of unit; lower contact of unit sharp.

| | | |
|---|---|---|
| *UNIT 2* | *Lindsay Formation, lower member* | *12.8m* |

Limestone: medium to dark grey, weathers light to medium grey to grey-brown; generally fine to medium grained and calcarenitic, interbedded with fine crystalline; medium to thick bedded (20-60 cm), with very thin shale partings present between some beds; fossiliferous with brachiopods common; lower contact of unit sharp and planar.

| | | |
|---|---|---|
| *UNIT 1* | *Verulam Formation* | *3.2m* |

Limestone and shale: dark grey, weathers light to medium grey; limestone beds are commonly fine crystalline, with some fine- to coarse-grained calcarenites also present; limestone thin bedded (5-10 cm), with 2-5 cm interbeds of dark grey shale and shaly limestone; fossiliferous with brachiopods most abundant.

| | |
|---|---|
| *Total thickness* | *41.0m* |

Exploration diamond drilling by St. Lawrence Cement Inc. was designed to test the stratigraphy underlying the licence area. The analytical results from the drill core as presented in Table NP-1-1 are reported by St. Lawrence to be typical for the licence area.

The alkalis of $K_2O$ and $Na_2O$ combined rarely exceed 1.0%. $SO_3$ is relatively constant at 0.60%. Chlorine at about 0.1% is most erratic, differing not only along strike and down dip but also across the bedding.

By combining the different members of the Lindsay Formation, a natural cement raw material can be obtained.

## QUARRY OPERATION

The current quarry occupies an area of approximately 100 ha. The quarry operates on two benches, each approximately 20 m high, the upper bench varying in places to 16.7 m. The north and east faces of the upper bench are thin bedded with some shale in the east face. The west face of the upper bench is characterized by more massive bedding with a higher carbonate content stone.

The lower bench was opened in 1985. It is 20 m in height and is composed of two distinct layers. The lower 7.6 m of the bench has a higher carbonate content and is being used as a sweetener stone.

Blasting in the quarry is conducted using a 20 cm R40 Pesageri rotary percussion drill on a 6.7 m x 7.3 m pattern. The explosive agent is AN/FO with a 6% fuel mix at a rate of 170 g/t. The quarry reaches a maximum depth of 41.0 m.

Water infiltration is from surface runoff and is controlled by a large sump in the top bench equipped with single 10 in. and 8 in. horizontal turbine pumps. The lower bench is drained by two 6 in. horizontal turbine pumps.

Shot rock is loaded by three 15-yd. LeTourneau loaders into two 105-ton, one 85-ton and three 75-ton Euclid rear-dump trucks. The average haul distance to the primary crushers is 300 m.

**TABLE NP-1-1. OGDEN POINT QUARRY, ST. LAWRENCE CEMENT, DRILL HOLE CHEMICAL ANALYSIS.**

| Hole # | Depth (ft) | LOI | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO | $SO_3$ | $K_2O$ | $Na_2O$ | Cl | Total | $C_3S$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U-22 | 0-50 | 35.06 | 12.58 | 3.69 | 1.51 | 43.18 | 1.92 | 0.78 | 0.81 | 0.17 | 0.098 | 99.80 | 82.90 |
| U-22 | 50-100 | 36.23 | 12.08 | 3.45 | 1.24 | 44.02 | 1.85 | 0.60 | 0.72 | 0.16 | 0.142 | 100.49 | 97.69 |
| U-22 | 100-150 | 35.47 | 13.18 | 3.79 | 1.38 | 42.75 | 2.08 | 0.58 | 0.77 | 0.16 | 0.148 | 100.29 | 71.69 |
| U-22 | 150-200 | 36.83 | 10.05 | 3.36 | 1.25 | 44.83 | 2.16 | 0.61 | 0.66 | 0.14 | 0.123 | 100.01 | 129.85 |
| U-22 | 200-250 | 39.22 | 6.97 | 2.13 | 0.77 | 48.17 | 2.11 | 0.47 | 0.50 | 0.06 | 0.042 | 100.45 | 207.95 |
| U-22 | 250-300 | 39.00 | 7.01 | 2.17 | 0.81 | 48.11 | 2.23 | 0.60 | 0.49 | 0.08 | 0.042 | 100.53 | 206.02 |
| U-22 | 300-350 | 40.57 | 4.58 | 1.14 | 0.50 | 50.75 | 2.17 | 0.52 | 0.31 | 0.08 | 0.042 | 100.66 | 270.76 |
| R-16 | 0-50 | 37.56 | 9.29 | 2.44 | 1.09 | 56.14 | 1.64 | 0.62 | 0.55 | 0.06 | 0.068 | 99.45 | 160.48 |
| R-16 | 50-100 | 34.33 | 13.81 | 4.23 | 1.58 | 41.92 | 1.76 | 0.77 | 0.95 | 0.10 | 0.066 | 99.52 | 54.16 |
| R-16 | 100-150 | 35.78 | 12.21 | 3.56 | 1.27 | 43.73 | 1.60 | 0.61 | 0.76 | 0.05 | 0.077 | 99.63 | 93.40 |
| R-16 | 150-200 | 35.75 | 12.68 | 3.78 | 1.30 | 43.32 | 1.71 | 0.58 | 0.75 | 0.18 | 0.096 | 100.14 | 82.27 |
| R-16 | 200-250 | 36.99 | 10.27 | 3.43 | 1.22 | 44.94 | 1.69 | 0.60 | 0.66 | 0.10 | 0.091 | 99.99 | 127.41 |
| R-16 | 250-300 | 38.97 | 7.24 | 2.38 | 0.79 | 47.80 | 2.30 | 0.48 | 0.52 | 0.10 | 0.081 | 100.57 | 198.33 |
| R-16 | 300-350 | 38.59 | 7.63 | 2.60 | 0.90 | 47.16 | 2.32 | 0.62 | 0.55 | 0.11 | 0.070 | 99.82 | 186.25 |
| R-16 | 350-400 | 40.35 | 4.86 | 1.25 | 0.55 | 50.13 | 1.86 | 0.56 | 0.27 | 0.03 | 0.076 | 99.89 | 263.67 |
| O-22 | 0-50 | 37.43 | 9.85 | 2.51 | 1.09 | 45.72 | 1.63 | 0.62 | 0.56 | 0.09 | 0.023 | 99.51 | 149.76 |
| O-22 | 50-100 | 34.58 | 13.50 | 3.91 | 1.54 | 42.18 | 1.62 | 0.76 | 0.87 | 0.11 | 0.025 | 99.09 | 63.46 |
| O-22 | 100-150 | 35.57 | 13.14 | 3.58 | 1.29 | 43.12 | 1.57 | 0.61 | 0.74 | 0.10 | 0.028 | 99.73 | 77.84 |
| O-22 | 150-200 | 35.38 | 13.27 | 3.87 | 1.34 | 42.89 | 1.69 | 0.57 | 0.78 | 0.16 | 0.026 | 99.77 | 70.06 |
| O-22 | 200-250 | 37.48 | 9.90 | 3.13 | 1.14 | 45.46 | 1.59 | 0.59 | 0.61 | 0.07 | 0.040 | 100.01 | 139.42 |
| O-22 | 250-300 | 37.45 | 9.43 | 2.39 | 0.79 | 47.61 | 1.50 | 0.50 | 0.54 | 0.09 | 0.033 | 100.01 | 197.22 |
| O-22 | 300-350 | 38.59 | 7.68 | 2.41 | 0.86 | 47.32 | 1.50 | 0.63 | 0.52 | 0.10 | 0.042 | 99.64 | 191.54 |
| O-22 | 350-400 | 39.49 | 5.11 | 1.12 | 0.46 | 50.22 | 1.43 | 0.52 | 0.23 | 0.06 | 0.034 | 99.68 | 264.27 |

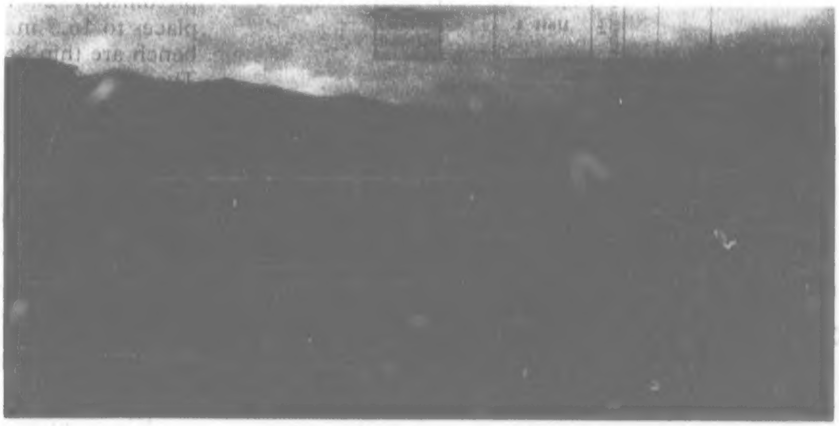


**Photo NP-1-1.**
**15-YD. LETOURNEAU FRONT END LOADER LOADING SHOT ROCK AT THE WEST FACE OF THE OGDEN POINT QUARRY.**

## PROCESSING

A process flow sheet is shown in Figure NP-1-3.

The primary crusher, a 54 in., 400 hp belt driven gyratory with a capacity of 2,000 tons per hour, is set in the quarry floor. Primary crushed material (-8 in.) is transported 550 m by a 48 in. covered belt conveyor to a 10,000 ton surge pile.

The material is reclaimed from the surge pile by a 48 in. conveyor and delivered 490 m to a 100,000 ton stockpile. A transfer station at the stockpile transfers the material to a 42 in. conveyor which delivers the stone 350 m to a second transfer station. At this point, the

Photo NP-1-2.
**SHIP LOADOUT AT OGDEN POINT QUARRY.**

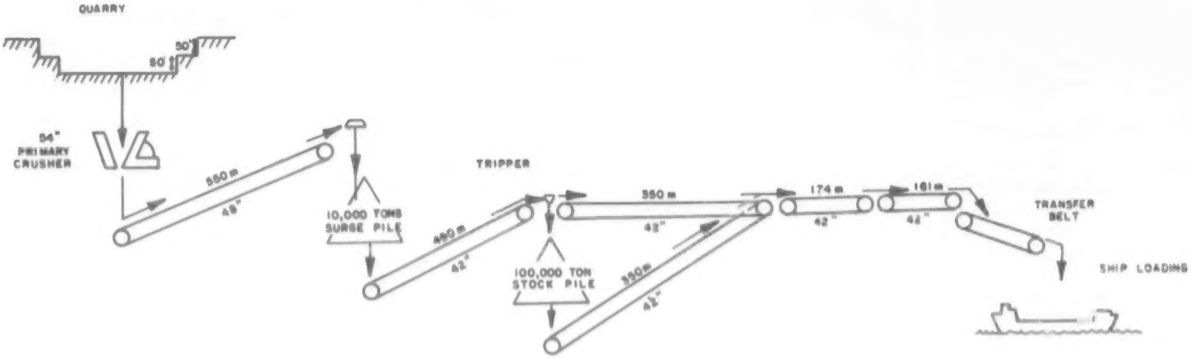

QUARRY
50'
80'
54"
PRIMARY
CRUSHER
550 m
48"
10,000 TONS
SURGE PILE
480 m
42"
TRIPPER
100,000 TON
STOCK PILE
350 m
42"
350 m
42"
174 m
42"
161 m
42"
TRANSFER
BELT
SHIP LOADING

Figure NP-1-3. PROCESS FLOW SHEET FOR OGDEN POINT QUARRY.

material is transferred to two 42 in. conveyors and onto belts leading to the ship loader. Material which is not loaded directly is reclaimed from the stockpile by a 350 m, 42 in. belt which then transfers to the belts leading to the ship loader. All belts are covered. Water sprays are fitted at the primary crusher and at the ship loader to control dust.

The stone is shipped to the St. Lawrence Cement plant (site MA-1, Maple District) at Clarkson (Mississauga).

## REFERENCES

Hewitt, 1960, p.49–51
Liberty, 1960c, p.3
Hewitt, 1964a, p.29–30
Mirynech and Liberty, 1964, p.35
Winder, 1964
Blair, 1965, p.52–54
Winder, 1966
Lee and Winder, 1967
Hewitt and Vos, 1972, p.41–42
Dolar-Mantuani, 1975, p.29–40
Carson, 1981d, Sect. D4 and D5

## MAPS

Liberty, 1960d, GSC Map 17-1960
Carson, 1980b, OGS Map P.2375

## NP-2 TRENTON GRAVEL PRODUCTS LTD. — CONSECON QUARRY

### LOCATION AND OWNERSHIP

The Consecon Quarry is located 2 km southeast of Consecon just east of Highway 33, in Lot 107, Concession 5 Bayside, Hillier Township, Prince Edward County (Figure NP-2-1). The quarry is owned and operated intermittently by Trenton Gravel Products Ltd., a division of Harnden and King Construction Limited, and was formerly owned by H. J. McFarland Construction Company. The quarry licence covers an area of 20.3 ha.

### GEOLOGY

The 11.2 m deep quarry has been excavated into the top of an east-west trending ridge of thin-bedded, nodular limestone of the lower member, Lindsay Formation. A second, currently inactive quarry, which exposes a similar section, is located immediately across Highway 33 on the west side. The bedrock surface on the ridge is covered with less than 0.25 m of overburden.

#### Geological Section

| | Thickness |
|---|---|
| *UNIT 1 Lindsay Formation, lower member* | *11.2 m* |
| Limestone: light grey-brown to light grey, weathers light grey; microcrystalline alternating with fine- to coarse-grained bioclastic and calcarenitic limestone; ranges from thin to thick bedded (5-50 cm), with most thin bedded (5-10 cm), sharp contacts, ranging from planar to undulating, with thin shale partings common between beds; very fossiliferous, with brachiopods most abundant; upper 4 m displays distinct nodular texture, becoming very rubbly in uppermost 0.5 m. | |
| *Total thickness* | *11.2 m* |

### CHEMICAL ANALYSES *

| Above Floor (m) | Components in Percent 5.24 - 7.07 | 3.41 - 5.24 | 0 - 11.2 |
|---|---|---|---|
| $SiO_2$ | 11.80 | 9.79 | 14.60 |
| $Al_2O_3$ | 2.90 | 2.50 | 3.68 |
| $Fe_2O_3$ | 1.03 | 0.93 | 1.34 |
| MgO | 1.28 | 1.48 | 1.60 |
| CaO | 44.8 | 45.9 | 42.1 |
| $P_2O_5$ | 0.06 | 0.07 | 0.05 |
| $SO_3$ | 0.23 | 0.47 | 0.58 |
| L.O.I. | 37.1 | 38.0 | 35.3 |
| Total | 99.2 | 99.1 | 99.3 |

* *after Hewitt and Vos, 1972, p.30.*

### QUARRY OPERATION

The quarry at present totals some 4 ha and is operated intermittently on a single 4.3 m lift. A drill pattern of 3 m x 3 m is used with 7.6 cm diameter holes, blasting conditions are dry and AN/FO is used as a bulk explosive. Crushing is contracted from within house.

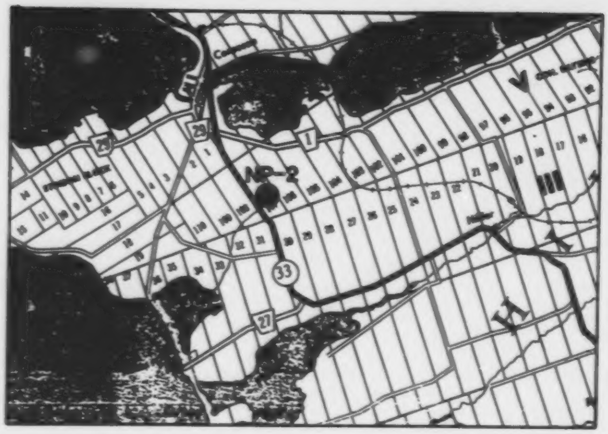


Figure NP-2-1. LOCATION MAP FOR CONSECON QUARRY.

### PRODUCTS

Granular "A"
Granular "B"

### REFERENCES

Goudge, 1938, p. 160
Hewitt, 1964a, p. 31
Hewitt and Vos, 1972, p. 30
Williams and Trotter, 1984

### MAPS

Carson, 1980b, OGS Map P.2375

## NP-3 H.J. McFARLAND CONSTRUCTION CO. — MOUNTAIN VIEW QUARRY

### LOCATION AND OWNERSHIP

H. J. McFarland Construction Company intermittently operates this quarry east of Mountain View, in Lots 64-65, Concession 4, Ameliasburgh Township, Prince Edward County (Figure NP-3-1). The quarry licence covers an area of 15.75 ha.

### GEOLOGY

Nodular limestone of the lower member, Lindsay Formation occurs in the 8.4 m deep quarry, which consists of two equal depth lifts. The most common lithology is a light grey, thin-bedded, very fine-crystalline limestone, interbedded with rare, thin shale partings. Also present are 10 cm thick beds of coarse-crystalline, bioclastic limestone, usually very fossiliferous. The uppermost metre in the quarry weathers into thin rubbly beds.

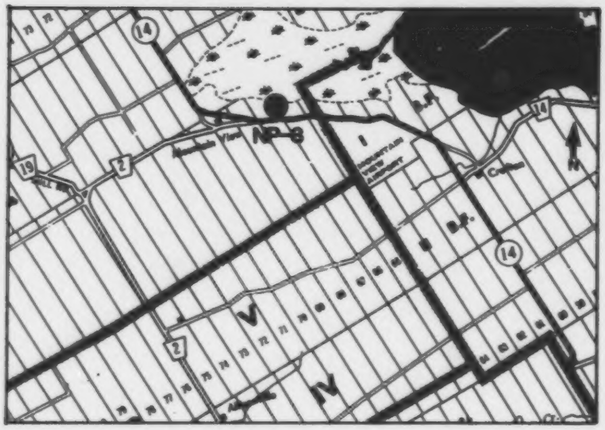


Figure NP-3-1. LOCATION MAP FOR MOUNTAIN VIEW QUARRY.

### Geological Section

*Thickness*

*UNIT 1 Lindsay Formation, lower member* *8.4m*

Limestone: blue-grey to medium grey, weathers light grey to light brown; very fine crystalline, with some coarse-crystalline beds, usually bioclastic; thin bedded (5–7 cm), with rare thin shale partings, commonly producing a nodular texture, coarser crystalline beds up to 10 cm thick; very fossiliferous with abundant shelly and trace fossils; uppermost metre of quarry very rubbly.

*Total thickness* *8.4m*

### REFERENCES

Liberty, 1960a, p. 7

### MAPS

Liberty, 1960b, GSC Map 45–1960

## NP-4 HARVEY PUTNAM — CANNIFTON QUARRY

### LOCATION AND OWNERSHIP

This quarry, owned and operated by Mr. Harvey Putnam, was opened in 1983 in Lot 10, Concession 3, Thurlow Township, Hastings County, at the intersection of Highways 37 and 401, 2 km north of Belleville (Figure NP–4–1). The property has a licensed area of approximately 20 ha.

### GEOLOGY

The 6.2 m deep quarry exposes thin–bedded limestones and interbedded thinner shales of the Verulam Formation. Glacial overburden around the quarry site is thin, ranging from 0.5 m to 1 m in thickness.

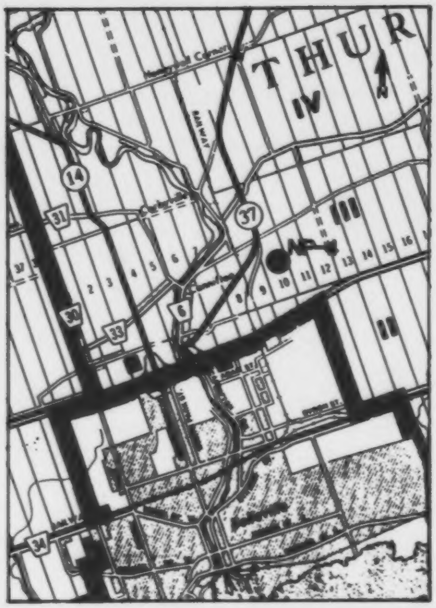


Figure NP–4–1. LOCATION MAP FOR CANNIFTON QUARRY.

### Geological Section

*Thickness*

*UNIT 1 Verulam Formation* *6.2m*

Interbedded limestone and shale: dark grey, weathers medium grey to grey brown; limestone either fine crystalline or coarse crystalline and bioclastic; thin- bedded (3–10 cm) limestone with thin interbeds (2–4 cm) of shale; sharp, planar to slightly undulating contacts; very fossiliferous.

*Total thickness* *6.2m*

### QUARRY OPERATION

Overburden is stripped by a Lorain 6 yd. loader and piled along the quarry limits. The quarry is situated in the southern part of the property and is advancing in two lifts towards the southeast boundary. On reaching this limit, development will continue to the east. Drilling and blasting is contracted; a 2.1 m x 2.1 m pattern is used with 7.6 cm diameter holes. Nilite (AN/FO) is used as a bulk explosive, primed with Tovex (slurry cartridges) and initiated with electric caps. Approximately 10,000 tonnes of rock are blasted on a single shot.

### PROCESSING

Crushing was performed on contract from the start of operations in 1983 until 1986, when Harvey Putnam took over the work.

The blasted rock is loaded by a Hough H100–C 5 yd. loader and transported to the primary crusher

Photo NP-4-1.
VIEW OF CANNIFTON QUARRY
(LOOKING NORTH).

(Cedarapids 30 in. x 30 in. impeller). The product is separated by a 5 ft. x 10 ft. double-deck Dillon screen. The +3 in. oversize material is returned to the crusher; finished products are stockpiled by a 100 ft. stacker.

### PRODUCTS

3 in. Crusher Run
7/8 in. Crusher Run
5/8 in. Crusher Run
3 in. Clear Stone
1 1/4 in. Clear Stone
3/4 in. Clear Stone
Tile Bed Stone

### REFERENCES

None

### MAPS

None

## NP-5 H.J. McFARLAND CONSTRUCTION CO. — POINT ANNE (BELLEVILLE) QUARRY

### LOCATION AND OWNERSHIP

The very large quarry located at Point Anne, 7 km east of Belleville, in Lots 16–27, Concessions 1 and Broken Front, Thurlow Township, Hastings County, is owned by Lafarge Canada Inc. and was operated as a source of stone for the manufacture of cement (Figure NP–5–1). Operations ceased in 1981 and the quarry is now partially filled with water. Subsequently, H.J. McFarland Construction Co. has excavated into the east face of the upper lift to obtain stone for aggregate, under an operating agreement with Standard Industries Ltd. (a division of Lafarge). The property has been in operation since the late 1800s. The quarry licence covers an area of 619.6 ha.

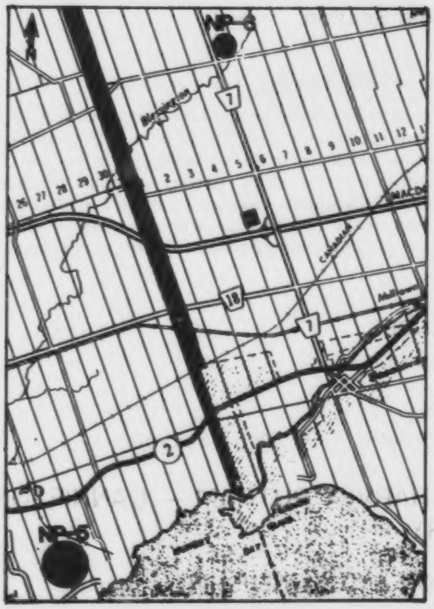


Figure NP-5-1. LOCATION MAP FOR POINT ANNE (BELLEVILLE) QUARRY.

### GEOLOGY

The quarry is over 30 m deep and when dry exposes limestones of the Gull River and Bobcaygeon Formations

(Hewitt, 1960). Above the present water level, up to 10 m of the Bobcaygeon Formation are still exposed, although inaccessible. At the newly exposed section in McFarland's quarry, 8 m of generally thin- to medium-bedded, microcrystalline to medium-crystalline limestone of the Bobcaygeon Formation is exposed. Glacial overburden around the original quarry varied from 1 to 5 m in thickness.

### REFERENCES

Goudge, 1938, p.90–92
Hewitt, 1960, p. 57–61
Hewitt, 1964a, p. 31
Blair, 1965, p.52–54
Hewitt and Vos, 1972, p. 16

### MAPS

Liberty, 1960b, GSC Map 45–1960
Carson, 1981a, OGS Map P.2412

## NP-6 H.J. McFARLAND CONSTRUCTION CO. — LONG QUARRY

### LOCATION AND OWNERSHIP

The Long Quarry is located in Lot 6, Concession 3, Tyendinaga Twp., Hastings County and is 6 km north of Shannonville (Figure NP-6-1).

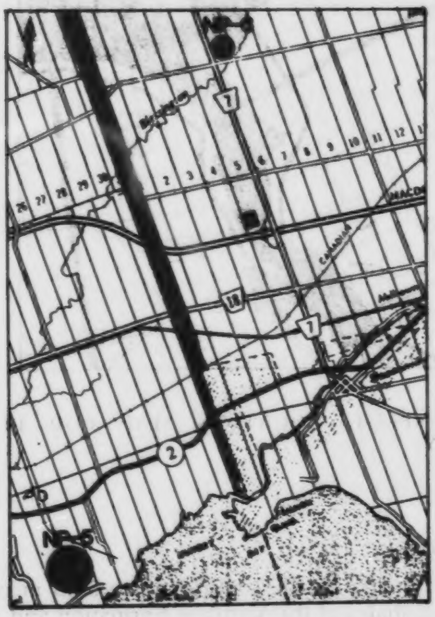


**Figure NP-6-1. LOCATION MAP FOR LONG QUARRY.**

The quarry is owned by Mr. Arthur Long, licensed to Charles H. Demill Construction Ltd., and is leased and operated by H. J. McFarland Construction Co. The property has a licensed area of approximately 24 ha. The excavated area of the quarry is approximately 12 ha. The quarry operates from April to November.

### GEOLOGY

The 6.7 m deep quarry exposes interbedded limestones and shales of the Verulam Formation. The limestones vary from very fine-crystalline to medium-crystalline and bioclastic. The gently northward-rising bedrock surface results in higher quarry faces at the north end of the quarry. Glacial overburden around the quarry is up to 2 m thick.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 1 Verulam Formation* | *6.7m* |
| Interbedded limestone and shale: dark grey, weathers medium grey to grey-brown; either very fine crystalline or medium crystalline and bioclastic; thin to medium bedded (5-15 cm) with shale beds up to 5 cm thick; sharp, slightly undulating to planar contacts; very fossiliferous. | |
| *Total thickness* | *6.7m* |

### QUARRY OPERATION

Overburden is stripped by Caterpillar 988 (7 yd.) loader and D8 bulldozer. The quarry limits have been reached to the south, west and east and it is advancing northward on a single 6.7 m lift. Drilling and blasting is subcontracted; a 2.6 m x 2.6 m drill pattern is used with 7.6 cm diameter holes. AN/FO (Amex) is used for the column charge, primed with Forcite 75% stick powder and initiated by electric caps. A Flygt 2 in. electric submersible pump handles dewatering of the quarry.

### PROCESSING

The blasted stone is transported approximately 50 m by Cat 988 loader to the primary feed hopper. Primary crushing is by Cedarapids 36 in. x 45 in. double impeller crusher. The crushed stone (– 4 in.) is sent to a 40-ton surge bin and fed to an 8 ft. x 20 ft. triple-deck Tyler screen. The top deck produces a – 4 in. + 1 1/4 in. oversize that is sent to a secondary crusher (4 ft. Symons short head), the middle deck produces – 1 1/4 in., + 1 in. or – 1 1/4 in., + 3/4 in. tile bed stone, and the bottom deck produces – 3/4 in. + 1/4 in. or 100% – 1 in. + 1/4 in. and – 1/4 in. screenings. The bottom deck oversize product is weighed by belt scale and sent by field conveyor to an 80 ft. radial stacker. The – 1/4 in. screenings are sent to an 80 ft. radial stacker and repiled by Michigan 125-III-A (4 yd.) loader. The operation has a washing facility that produces 5/8 in. and 3/8 in. chips from the bottom deck oversize.

### PRODUCTS

+9 in. Riprap

Photo NP-6-1. PROCESSING PLANT AT LONG QUARRY (LOOKING WEST).

-9 in. +4 in. Gabion Stone
6 in. Crusher Run
4 in. Crusher Run
7/8 in. Crusher Run
5/8 in. Crusher Run
-1 1/2 in. +3/4 in. Tile Bed Stone
Screenings
HL3
HL4
HL8

### REFERENCES

None

### MAPS

Liberty, 1960b, GSC Map 45-1960
Carson, 1981a, OGS Map P.2412

## NP-7 LAKE ONTARIO CEMENT LTD. — PICTON QUARRY AND PLANT

### LOCATION AND OWNERSHIP

Lake Ontario Cement Ltd. operates a large quarry and cement plant on a 405 ha property on the west shore of Picton Bay, 4 km northeast of Picton in Lots 13 to 18, Concession 1, Sophiasburg Township, Prince Edward County (Figure NP-7-1). Highway 49 passes through the property. The cement plant is equipped with four dry process kilns, two of which are maintained on standby. The original plant was built in 1958 and has been subject to several modernizations and expansions, the last being in 1978.

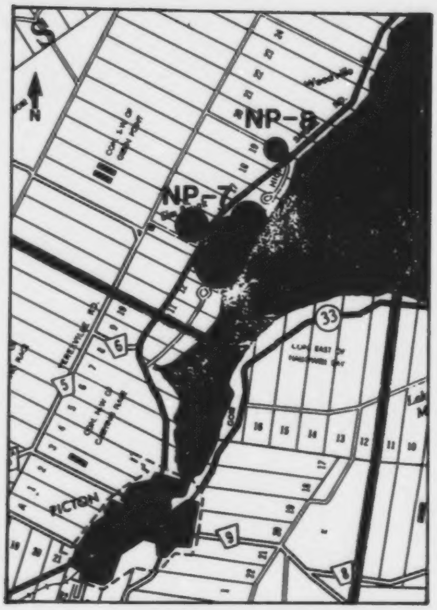


Figure NP-7-1. LOCATION MAP FOR PICTON QUARRY.

### GEOLOGY

The main quarry to the south exposes 34.5 m of limestones and shales of the Verulam Formation and 19.5 m of limestones of the overlying lower member, Lindsay Formation (Figure NP-7-2). A total of 54 m of strata is exposed in three large lifts in this quarry. The new quarry

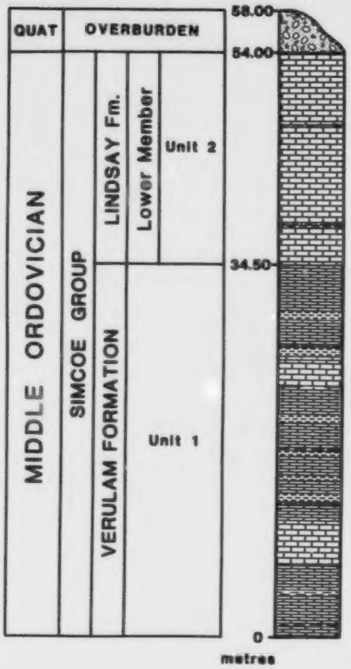


Figure NP-7-2. STRATIGRAPHIC COLUMN FOR PICTON QUARRY.

to the north exposes about 10 m of the Lindsay Formation.

Up to 4 m of glacial overburden, which was previously used as a source of silica and clay, overlies a massive, grey, medium-bedded limestone of the Lindsay Formation. These rocks have a very shallow dip to the south and trend slightly north of west.

The Verulam Formation consists of interbedded limestones and shale. The limestone ranges from fine-crystalline, non-fossiliferous limestone to coarse-grained bioclastic calcarenite. The interbedded shales are commonly burrowed. The overlying lower member of the Lindsay Formation consists of medium-bedded limestones which range from fine to medium-crystalline. These limestone beds commonly are separated by very thin, undulating shale partings which impart a distinctive nodular texture to this member.

On the western side of the main quarry an ultramafic dyke is visible. Recent paleomagnetic and K-Ar age-dating studies conducted on this rock revealed that the intrusive was emplaced during the Jurassic (Barnett et al., 1984).

Drillhole No. 85-1 was drilled by Lake Ontario Cement in 1985 in the immediate vicinity of the Main Quarry and analysed over its entire length of 60.96 m. The analytical results as reported by Lake Ontario Cement are presented in Tables NP-7-1 and NP-7-2. Precise correlation of the Lindsay and Verulam Formations with the analytical results is not available but the Lindsay Formation is characterized by lower $SiO_2$ (7.74% versus 13.58%), $Al_2O_3$ (1.85% versus 3.91%), $K_2O$, $Fe_2O_3$, $TiO_2$, $P_2O_5$ and F, and higher CaO (48.4% versus 42.85%) and L.O.I. The content of MgO is fairly constant within the range of 0.97% to 1.71%.

The high lime section of the Lindsay Formation encountered at Lake Ontario's quarry correlates with the high lime horizon in the Ogden Point Quarry (NP-1). These two sections of the Lindsay are comparable even to the higher Cl and $K_2O$ zone underlying the high lime section.

## Geological Section

*Thickness*

*UNIT 2 Lindsay Formation, lower member* *19.5m*

Limestone: dark grey, weathers light to medium grey; fine to medium crystalline; medium bedded (10 - 25 cm), with rare, very thin shale and shaly limestone partings present between some beds, otherwise contacts sharp and planar; sparsely fossiliferous; uppermost 5-10 m around the quarry exhibits a nodular to rubbly texture of varying amounts, best developed in areas of jointing; bedrock surface usually weathers into rubble; lower contact of unit sharp and planar, enhanced by a zone of water seepage; top of second lift 5.5 m above base of unit.

*UNIT 1 Verulam Formation* *34.5m*

Interbedded limestone and shale: dark grey, weathers medium grey; limestones either fine crystalline or medium to coarse grained, bioclastic and calcarenitic; limestone thin (5-10 cm) to rarely medium bedded (10-15 cm) with thin (2-8 cm) interbeds of shale; thin calcite veins coat joint surfaces; very fossiliferous with abundant brachiopods, trilobites, bryozoans and crinoidal debris, shales commonly burrowed; top of first (lowest) lift 13.5 m above base of unit.

*Total thickness* *54.0m*

## QUARRY OPERATION

Lake Ontario Cement operates two quarries. The original, or South quarry, has been developed on three benches. The upper bench is 12 m in height and consists of massive-bedded high carbonate rock. The middle bench is 20 m high and is composed of thin-bedded, low carbonate rock. The lower bench is 12 m and is composed of a natural cement rock.

The new North quarry has been opened up on the north side of Highway 49. Access to the quarry is provided by a tunnel completed in 1985 that was developed by top drilling and blasting and has its roof epoxy bolted and screened. The tunnel is sufficiently wide to accommodate 35-ton trucks plus a 42 in. belt conveyor, which is planned for later installation. The North quarry has been designed on 10.6 m benches for possible aggregate production.

TABLE NP-7-1. TYPICAL CHEMICAL ANALYSES, PICTON QUARRY OF LAKE ONTARIO CEMENT CO.

| Depth | 0–10 | 10–15 | 15–20 | 20–25 | 25–30 | 30–35 | 35–40 | 40–45 | 45–50 |
|---|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 9.98 | 7.89 | 5.96 | 5.71 | 6.76 | 7.73 | 7.97 | 7.02 | 7.72 |
| $Al_2O_3$ | 1.99 | 1.94 | 1.46 | 1.39 | 1.55 | 1.89 | 1.94 | 1.58 | 1.86 |
| CaO | 48.3 | 48.3 | 49.6 | 50.0 | 48.8 | 49.1 | 48.0 | 48.9 | 47.8 |
| MgO | 0.97 | 1.41 | 1.26 | 1.18 | 1.32 | 1.39 | 1.37 | 1.37 | 1.45 |
| $Na_2O$ | 0.09 | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.03 | <0.01 | 0.01 |
| $K_2O$ | 0.37 | 0.30 | 0.13 | 0.12 | 0.22 | 0.32 | 0.2 | 0.23 | 0.27 |
| $Fe_2O_3$ | 0.85 | 0.90 | 0.77 | 0.74 | 0.92 | 0.98 | 0.87 | 0.83 | 0.94 |
| MnO | <0.01 | <0.01 | <0.01 | <0.01 | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| $TiO_2$ | 0.06 | 0.09 | 0.05 | 0.06 | 0.05 | 0.03 | 0.07 | 0.06 | 0.06 |
| $P_2O_5$ | 0.14 | 0.09 | 0.09 | 0.08 | 0.08 | 0.08 | 0.08 | 0.03 | 0.03 |
| $Cr_2O_3$ | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| L.O.I. | 37.8 | 38.8 | 39.9 | 39.3 | 39.5 | 38.8 | 38.5 | 39.2 | 38.5 |
| Sum | 100.7 | 99.8 | 99.3 | 98.6 | 99.2 | 100.5 | 99.1 | 99.3 | 98.8 |

| Depth | 50–55 | 55–60 | 60–65 | 65–70 | 70–75 | 75–80 | 80–85 | 85–90 | 90–95 |
|---|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 8.18 | 10.2 | 13.0 | 12.4 | 12.1 | 20.7 | 15.3 | 16.3 | 12.4 |
| $Al_2O_3$ | 2.07 | 2.68 | 3.84 | 3.60 | 3.37 | 5.97 | 4.55 | 4.95 | 3.59 |
| CaO | 47.8 | 46.1 | 43.4 | 44.3 | 44.8 | 36.1 | 41.6 | 39.8 | 43.7 |
| MgO | 1.38 | 1.36 | 1.55 | 1.47 | 1.50 | 1.71 | 1.45 | 1.45 | 1.34 |
| $Na_2O$ | 0.02 | 0.03 | 0.02 | 0.04 | 0.05 | 0.03 | 0.04 | 0.06 | 0.03 |
| $K_2O$ | 0.33 | 0.41 | 1.04 | 0.66 | 0.53 | 1.40 | 0.88 | 1.24 | 0.83 |
| $Fe_2O_3$ | 0.94 | 1.16 | 1.57 | 1.42 | 1.41 | 2.34 | 1.75 | 1.71 | 1.42 |
| MnO | <0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.03 | 0.02 | 0.01 | 0.01 |
| $TiO_2$ | 0.08 | 0.08 | 0.13 | 0.12 | 0.13 | 0.21 | 0.16 | 0.17 | 0.13 |
| $P_2O_5$ | 0.08 | 0.09 | 0.09 | 0.11 | 0.16 | 0.22 | 0.14 | 0.11 | 0.12 |
| $Cr_2O_3$ | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| L.O.I. | 33.4 | 36.5 | 34.8 | 35.3 | 35.8 | 29.5 | 33.4 | 32.5 | 35.4 |
| Sum | 99.3 | 98.7 | 99.5 | 99.5 | 99.9 | 98.3 | 99.3 | 98.5 | 99.0 |

| Depth | 95–100 | 100–105 | 105–110 | 110–115 | 115–120 | 120–125 | 125–130 | 130–135 | 135–140 |
|---|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 15.1 | 12.6 | 13.7 | 15.1 | 19.9 | 13.2 | 13.4 | 12.7 | 11.9 |
| $Al_2O_3$ | 4.37 | 3.48 | 3.56 | 4.26 | 5.70 | 3.69 | 3.79 | 3.53 | 3.32 |
| CaO | 41.4 | 44.8 | 43.1 | 41.8 | 37.7 | 43.5 | 42.8 | 44.0 | 44.5 |
| MgO | 1.45 | 1.37 | 1.46 | 1.46 | 1.71 | 1.41 | 1.34 | 1.30 | 1.28 |
| $Na_2O$ | 0.05 | 0.03 | 0.02 | 0.06 | 0.09 | <0.01 | 0.06 | 0.01 | 0.02 |
| $K_2O$ | 0.98 | 0.71 | 0.75 | 0.90 | 1.27 | 0.73 | 0.82 | 0.71 | 0.65 |
| $Fe_2O_3$ | 1.44 | 1.32 | 1.26 | 1.51 | 1.92 | 1.37 | 1.32 | 1.18 | 1.20 |
| MnO | <0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | <0.01 | 0.01 |
| $TiO_2$ | 0.15 | 0.12 | 0.12 | 0.15 | 0.20 | 0.13 | 0.13 | 0.13 | 0.11 |
| $P_2O_5$ | 0.11 | 0.11 | 0.10 | 0.12 | 0.13 | 0.11 | 0.13 | 0.11 | 0.11 |
| $Cr_2O_3$ | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| L.O.I. | 34.2 | 36.0 | 35.5 | 34.3 | 30.9 | 35.4 | 35.2 | 35.9 | 36.4 |
| Sum | 99.3 | 100.6 | 99.6 | 99.8 | 99.6 | 99.6 | 99.1 | 99.7 | 99.6 |

| Depth | 140–145 | 145–150 | 150–155 | 155–160 | 160–165 | 165–170 | 170–175 | 175–180 | 180–185 | 185–190 |
|---|---|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 12.2 | 10.1 | 15.6 | 15.1 | 14.0 | 15.7 | 13.9 | 11.6 | 10.5 | 11.2 |
| $Al_2O_3$ | 3.13 | 2.68 | 4.39 | 3.96 | 3.74 | 4.44 | 4.30 | 3.53 | 3.28 | 3.89 |
| CaO | 44.4 | 45.9 | 40.7 | 41.8 | 42.8 | 40.7 | 41.9 | 44.2 | 45.0 | 43.6 |
| MgO | 1.36 | 1.22 | 1.61 | 1.66 | 1.43 | 1.49 | 1.38 | 1.40 | 1.38 | 1.45 |
| $Na_2O$ | <0.01 | <0.01 | <0.01 | 0.04 | 0.04 | 0.05 | 0.06 | 0.07 | 0.04 | 0.04 |
| $K_2O$ | 0.66 | 0.52 | 1.08 | 0.82 | 0.76 | 1.01 | 0.89 | 0.62 | 0.57 | 0.81 |
| $Fe_2O_3$ | 1.17 | 1.05 | 1.44 | 1.35 | 1.33 | 1.60 | 1.49 | 1.24 | 1.14 | 1.29 |
| MnO | 0.01 | 0.01 | <0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | <0.01 | <0.01 |
| $TiO_2$ | 0.12 | 0.09 | 0.16 | 0.13 | 0.14 | 0.15 | 0.15 | 0.12 | 0.12 | 0.13 |
| $P_2O_5$ | 0.12 | 0.10 | 0.11 | 0.11 | 0.11 | 0.18 | 0.15 | 0.10 | 0.10 | 0.10 |
| $Cr_2O_3$ | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| L.O.I. | 36.2 | 37.6 | 33.9 | 34.4 | 35.0 | 33.6 | 34.7 | 36.4 | 37.2 | 36.5 |
| Sum | 99.5 | 99.4 | 99.1 | 99.5 | 99.4 | 99.0 | 99.0 | 99.3 | 99.4 | 99.0 |

*Note: The boundary between the Verulam and Lindsay Formations is found at approximately 50-foot depth.*

TABLE NP-7-2. TYPICAL CHEMICAL ANALYSES, PICTON QUARRY OF LAKE ONTARIO CEMENT CO.

| Depth | 0-10 | 10-15 | 15-20 | 20-25 | 25-30 | 30-35 | 35-40 | 40-45 | 45-50 | 50-55 |
|---|---|---|---|---|---|---|---|---|---|---|
| F (ppm) | 240 | 260 | 280 | 200 | 220 | 240 | 260 | 250 | 240 | 290 |
| S (%) | 0.21 | 0.38 | 0.35 | 0.41 | 0.52 | 0.49 | 0.44 | 0.47 | 0.54 | 0.54 |
| Cl (ppm) | 200 | 200 | 250 | 300 | 200 | 150 | 200 | 200 | 200 | 200 |

| Depth | 55-60 | 60-65 | 65-70 | 70-75 | 75-80 | 80-85 | 85-90 | 90-95 | 95-100 | 100-105 |
|---|---|---|---|---|---|---|---|---|---|---|
| F (ppm) | 340 | 520 | 500 | 550 | 810 | 550 | 620 | 560 | 620 | 630 |
| S (%) | 0.63 | 0.77 | 0.69 | 0.63 | 1.04 | 0.76 | 0.73 | 0.60 | 0.55 | 0.41 |
| Cl (ppm) | 250 | 200 | 150 | 100 | 150 | 100 | 50 | 200 | 150 | 100 |

| Depth | 105-110 | 110-115 | 115-120 | 120-125 | 125-130 | 130-135 | 135-140 | 140-145 | 145-150 | 150-155 |
|---|---|---|---|---|---|---|---|---|---|---|
| F (ppm) | 620 | 680 | 850 | 600 | 620 | 630 | 590 | 550 | 540 | 750 |
| S (%) | 0.44 | 0.48 | 0.67 | 0.50 | 0.45 | 0.35 | 0.38 | 0.35 | 0.31 | 0.43 |
| Cl (ppm) | 100 | 100 | 150 | 100 | 200 | 200 | 200 | 200 | 150 | 150 |

| Depth | 155-160 | 160-165 | 165-170 | 170-175 | 175-180 | 180-185 | 185-190 | 190-195 | 195-200 |
|---|---|---|---|---|---|---|---|---|---|
| F (ppm) | 660 | 720 | 740 | 620 | 640 | 630 | 660 | 560 | 660 |
| S (%) | 0.37 | 0.41 | 0.53 | 0.45 | 0.38 | 0.32 | 0.33 | 0.30 | 0.35 |
| Cl (ppm) | 250 | 200 | 200 | 250 | 300 | 250 | 400 | 300 | 550 |

*Note: the boundary between the Verulam and Lindsay Formations is found at approximately 55-foot depth.*

Access to the South pit is provided by 7.6 m wide roads to the pit floor and the intermediate benches. Haulage distances for transport of shot rock from the quarry face to the primary crusher vary from 460 m to 1,000 m.

Drilling is carried out with an Ingersoll-Rand DMD4 rig using 16.5 cm bits, on a 5.2 m x 5.8 m pattern to bench depth. The blasting agent is AN/FO, using prills and a 13% fuel mix for dry holes or a premix watergel for wet holes. Explosives requirements range from 4.5 to 7.0 kg per tonne of rock. Secondary breakage is required for shot rock from the first and third benches, and is done by drop ball, rock breaker or limited secondary blasting.

## PROCESSING

Loading of shot rock is by one 12 yd. and four 7 yd. front-end loaders into two 50-ton Wabco and three 35-ton Wabco rear dump units. Material is delivered to a KVS 48 in. gyratory primary crusher set at -5 in. and having a capacity of 450 tons per hour. Material from the primary crusher is carried by a 42 in. belt conveyor equipped with a continuous weigh scale to a 60,000 tonne surge pile, that is is divided into two sections to separate the high carbonate and low carbonate material. The conveyor is on a swing mechanism to allow placement of the rock.

Primary crushed material is recovered from the surge pile by two parallel 36 in. conveyor systems. One system delivers material to a 48 in. Pennsylvania impact crusher which reduces the stone to -1/2 in. This crusher operates in closed circuit with Tyler screens. The second conveyor delivers material to a swing beam mill to reduce the rock to -3 in. size. Secondary crushed material is then conveyed directly to the roller mills, ball mills or to raw material storage.

Mill scale, Hay Bay sand and/or Potsdam Formation sandstone are added at the secondary crushing stage to yield the raw mix.

In general, material from the impact crusher (-1/2 in.) is delivered to the ball mills. Material from the swing beam mill (-3 in.) is delivered to the roller mill (also capable of accepting -1/2 in. material from the impact crusher).

There are two primary raw mills. The main raw mills are Loesche roller mills, installed in 1974, which combine the grinding, drying and classifying steps in one operation. Material from the roller mills is passed to the blending silos for final blending and storage.

Two 11 ft. x 20 ft., 1,250 hp KVS ball mills provide additional grinding capacity of 150 tons per hour. Material from the ball mills is also transferred to the blending and storage silos. Total raw feed storage capacity is 10,000 tons in 8 silos.

### KILNS

The primary kiln is an F.L. Smidth 17 ft. x 270 ft., 3,000 ton per day unit equipped with a four-stage preheater. The kiln is coal fired but can also be fired by gas. This kiln mostly uses material from the roller mills. There is a second Allis-Chalmers kiln measuring 13 ft. 6 in. x 500 ft. with a capacity of 1,100 tons per day. This kiln is used to supplement the capacity of the larger kiln and to produce low alkali clinker. The kiln is coal fired with gas firing as auxiliary, and processes raw mill mix from the ball mills.

Two 11 ft. x 375 ft., 650 tons per day, KVS kilns are maintained on standby. They are also coal fired.

Coal for the kilns is stored on the shore and trucked daily to a 1,000 ton storage bin where it is withdrawn and processed to -200 mesh in KVS and Raymond mills.

Raw kiln feed from the blending silos is transferred by airslide and screw pump to the 4-stage preheater tower. The preheater is equipped with two gas conditioners. The raw kiln feed enters the first stage of the preheater at 650°F and exits the fourth stage of the preheater at a temperature of 1,800°F. The preheater and kiln are controlled by an HP process controller and F.L. Smidth digital system. Both kilns are fitted with electrostatic precipitators.

Hot clinker is discharged to a grate cooling system, sized, and then passed to clinker storage. The second kiln also has a grate cooling system.

Chloride control has been troublesome as the chloride content in the stone is very erratic. Best operation of the preheater and kiln is achieved when $Cl_2$ content in the stone is below 0.02%. Chloride content is controlled through selective quarrying.

Clinker for export is moved by conveyor from storage to loading at dockside. Clinker and gypsum for grinding are recovered and passed to five finish grinding mills. These consist of two KVS 11 ft. x 20 ft., 1,250 hp ball mills and one F.L. Smidth 9.5 ft. x 26 ft., 1,250 hp mill and two 11 ft. 6 in. x 32 ft. 2,250 hp Allis-Chalmers ball mills. The mills are in closed circuit with air classifiers.

Finished cement is transferred by airslide and screw pump to storage in the packhouse (19,000 tons) or to storage in the dockside silos (16,800 tons). Shipment is by boat, bulk rail, truck, and in bags.

### PRODUCTS

Normal Portland
High Early Strength Portland
Sulfate Resisting Portland
Low Heat of Hydration Portland
Masonry Cement

### REFERENCES

Hewitt, 1960, p. 54-60
Hewitt, 1964a, p. 31-32
Blair, 1965, p.52-54
Hewitt and Vos, 1972, p. 27-28
Dolar-Mantuani, 1975
Barnett et al., 1984

### MAPS

Liberty, 1960b, GSC Map 45-1960

## NP-8 MILLER PAVING LIMITED — PRINCE EDWARD (PICTON) QUARRY

### LOCATION AND OWNERSHIP

The Prince Edward Quarry is located 8 km northeast of Picton in Lots 19 and 20, Concession 1, Sophiasburg Twp., Prince Edward County (Figure NP-8-1). The quarry was opened in 1976 by John Doranburg of Picton and in February of 1986, the property was purchased by Miller Paving Limited, the present operators. The quarry licence covers an area of 47.6 ha. The quarry is within a few hundred metres of the the waters of the Bay of Quinte. The northwest part of the quarry is under a separate licence of 8.1 ha held by H.J. McFarland Construction Co.

### GEOLOGY

The 6.4 m deep quarry exposes thin-bedded, nodular limestone of the lower member of the Lindsay Forma-

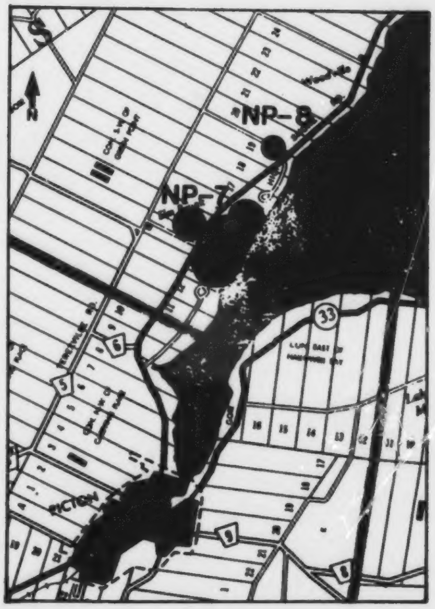


Figure NP-8-1. LOCATION MAP FOR PRINCE EDWARD (PICTON) QUARRY.

tion. The beds consist of fine– to medium–crystalline limestone with some interbeds of very coarse–grained calcarenites which are quite fossiliferous. Glacial overburden around the quarry is generally less than 0.5 m in thickness.

### Geological Section

| | | *Thickness* |
|---|---|---|
| *UNIT 1* | *Lindsay Formation, lower member* | *6.4m* |

Limestone: medium to dark grey, weathers light to medium grey; dominantly fine to medium crystalline with some beds very coarse grained and calcarenitic; thin-bedded (2–10 cm) with thin shale partings common between beds, undulating contacts producing a nodular texture, especially in uppermost 2 m of quarry; very fossiliferous, especially on bedding planes.

| | |
|---|---|
| *Total thickness* | *6.4m* |

### QUARRY OPERATION

The Prince Edward Quarry covers an area of about 8 ha on a lift of 6.4 m. Currently the primary products are crusher run materials, though a chemical analysis and marketing study of the stone is underway to determine other potential uses. Drilling and blasting is subcontracted, and a drill pattern of 2.4 m x 2.4 m is used with 7.6 cm diameter holes.

### PROCESSING

Crushing is performed by Miller Paving Limited with a portable system consisting of a primary impeller impactor and double–deck screen that is assembled as required.

### PRODUCTS

Armour Stone
3 in. Crusher Run
7/8 in. Granular "A"
5/8 in. Granular "A"
3/4 in. Clear
2 in. Oversize (Road Base)

### REFERENCES

Hewitt and Vos,1972, p. 34
Williams and Trotter, 1984

### MAPS

Carson, 1981a, OGS Map P.2412

## NP–9 TRENTON GRAVEL PRODUCTS LTD. — NAPANEE QUARRY

### LOCATION AND OWNERSHIP

The Napanee Quarry is located in Lot 12, Concession 1, Richmond Township, Lennox and Addington County, 3 km southwest of Napanee (Figure NP–9–1). The quarry was opened in 1972 by Covert Construction and purchased in 1984 by Trenton Gravel Products. The property is not within an area designated under the Pits and Quarries Control Act. The area of the quarry is approximately 2.5 ha.

### GEOLOGY

The 7 m deep quarry exposes interbedded limestones and shales of the Verulam Formation; the former varies from fine–crystalline limestone to coarse–grained calcarenite. The quarry is deeper at the north end because of the southerly sloping bedrock surface. Glacial overburden around the quarry is less than 1 m thick.

### Geological Section

| | | *Thickness* |
|---|---|---|
| *UNIT 1* | *Verulam Formation* | *7.0m* |

Interbedded limestone and shale: dark grey, weathers light grey–brown; limestone is either fine to medium crystalline or is coarse to very coarse grained, usually bioclastic or calcarenitic; gently undulating contacts; coarser crystalline limestone usually has small patches of calcite crystals, commonly the result of recrystallization of fossil debris; very fossiliferous with abundant brachiopods, trilobites, bryozoans, and crinoidal debris; shale may also contain varying amounts of very thin laminae of very fine–crystalline limestone.

| | |
|---|---|
| *Total thickness* | *7.0m* |

### QUARRY OPERATION

A single lift of 7 m is currently excavated, with potential for a second lift of approximately 6.0 m. Drilling and blasting is subcontracted: a 2.7 m x 2.7 m drill pattern is

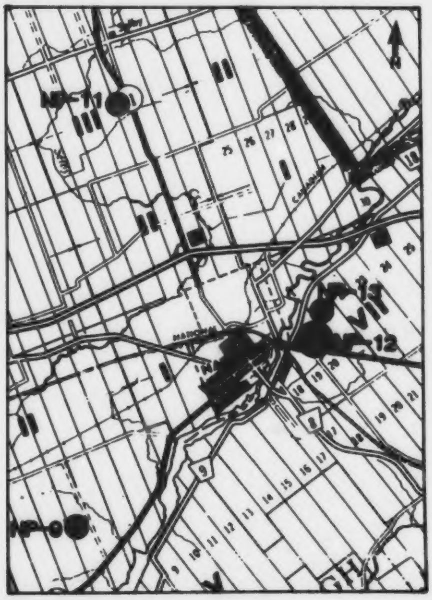


**Figure NP–9–1. LOCATION MAP FOR NAPANEE QUARRY.**

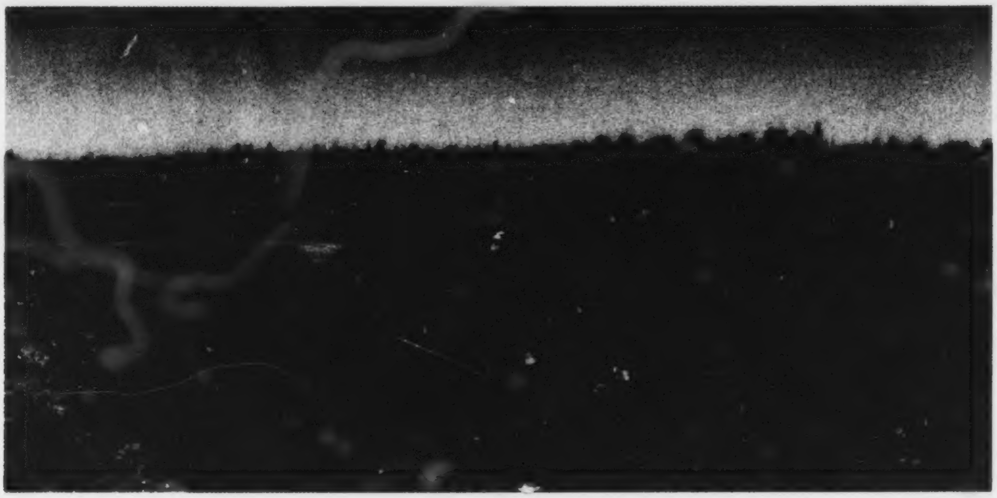


**Photo NP-9-1. STOCKPILE AREA AT NAPANEE QUARRY (LOOKING NORTHEAST).**

practised with 7.6 cm diameter drill holes. Crushing is performed on demand by an associated company (Harnden & King Construction Ltd.), using portable equipment.

### PRODUCTS

Gabion Stone 8 in. x 8 in.
7/8 in. Crusher Run
5/8 in. Crusher Run
1 1/2 in. Clear
3/4 in. Clear
Prime Rock -4 in.
Shot Rock
Brick Sand
Sand Fill

### REFERENCES

None

### MAPS

Carson, 1982a, OGS Map P.2497

## NP-10 H.J. McFARLAND CONSTRUCTION CO. — ROBLINDALE QUARRY

### LOCATION AND OWNERSHIP

The Roblindale Quarry is owned by H.J. McFarland Construction of Belleville and is located east of Roblindale village, about 10 km north of Highway 401, in Lot 1, Concession 6, Camden East Township, Lennox and Addington County (Figure NP-10-1). During field work in June 1986, the quarry was not in operation.

The quarry was very active in the 1940s and 1950s and was mined to a depth of 18.3 m on three lifts. The quarry is not in an area designated under the Pits and Quarries Control Act.

### GEOLOGY

The 18.3 m face exposes 3 m of the upper member of the Gull River Formation, overlain by 15.3 m of the lower member of the Bobcaygeon Formation (Figure NP-10-2). The contact between the formations is diffi-

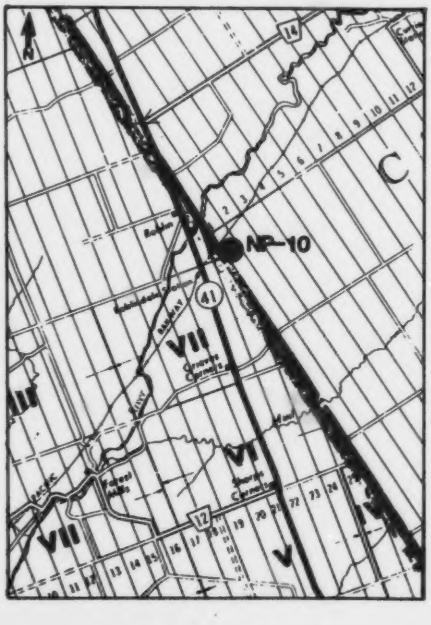


**Figure NP-10-1. LOCATION MAP FOR ROBLINDALE QUARRY.**

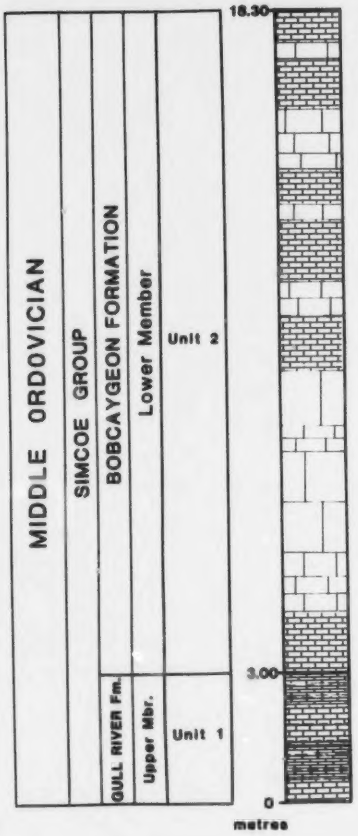


**Figure NP-10-2.** STRATIGRAPHIC COLUMN FOR ROBLINDALE QUARRY.

cult to see because extensive blasting in the quarry has created thinner beds than are usual through this interval.

The upper member of the Gull River Formation in this quarry consists of grey-brown, light grey weathering, microcrystalline, thin- to medium-bedded (7-12 cm) limestone, with thin dark grey shale partings commonly separating the limestone beds. The overlying lower member of the Bobcaygeon Formation is characterized by medium grey, light grey weathering, fine- to medium-crystalline and medium- to coarse-grained calcarenitic, medium- to thick-bedded (10-50 cm) limestone. Shale partings are generally absent through this interval.

The uppermost part of the section includes several massive beds, greater than 1 m thick. The formational contact is marked by a distinct limestone conglomerate in the Bobcaygeon Formation — microcrystalline limestone clasts occur in a matrix of fine- to medium-crystalline limestone. Glacial overburden around the top of the quarry is 1 to 3 m thick.

### Geological Section

*Thickness*

*UNIT 2 Bobcaygeon Formation, lower member* *15.3m*

Limestone: medium grey, weathering light grey, light brown in upper beds; fine to medium crystalline and medium to coarse grained calcarenitic, rarely microcrystalline; medium bedded to massive (10-50 cm in lower part, over 1 m in upper part); small patches of calcite crystals common in coarser calcarenites; generally fossiliferous, some beds contain many fragments of coral *Tetradium*; lowermost 0.3 m includes limestone conglomerate with microcrystalline clasts in a fine- to medium-crystalline matrix; lower contact of unit sharp and irregular, at base of conglomerate.

*UNIT 1 Gull River Formation, upper member* *3.0m*

Limestone: medium grey to grey-brown, weathers light grey; microcrystalline to fine crystalline; thin to medium bedded (7-12 cm) commonly separated by thin, dark grey shale partings; small patches of calcite crystals, "birdseye" texture, common in microcrystalline beds.

*Total thickness* *18.3m*

### REFERENCES

Goudge, 1938, p.125
Hewitt, 1960, p.61-63
Hewitt, 1964a, p.32
Sabina, 1970, p.94-95
Hewitt and Vos, 1972, p.41
Verschuren et al., 1985, p.50

### MAPS

Liberty, 1963b, GSC Map 24-1963
Hewitt, 1964e, ODM Map 2053
Carson, 1981b, OGS Map P.2411

## NP-11 CUSTOM MOBILE CONCRETE — SELBY QUARRY

### LOCATION AND OWNERSHIP

This small quarry located in Lot 21, Concession 3, Richmond Township, Lennox and Addington County is used by Custom Mobile Concrete as a source of aggregate for concrete (Figure NP-11-1).

### GEOLOGY

The 6.0 m deep quarry exposes thin-bedded shaly limestone of the Verulam Formation beneath glacial overburden that is generally 1 m thick. A very old abandoned quarry (Liberty, 1971d), almost totally filled in, is located just to the east between Highway 41 and the concrete plant.

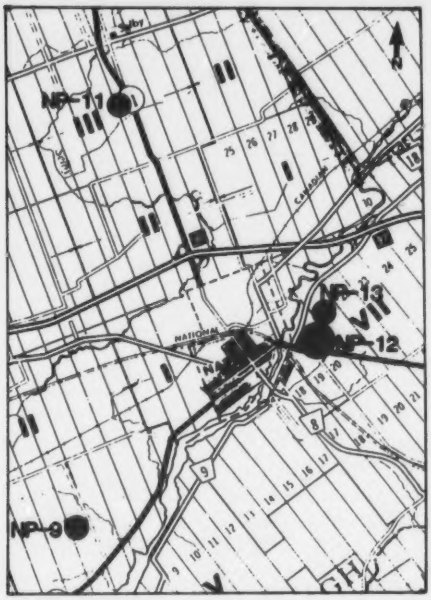


Figure NP-11-1. LOCATION MAP FOR SELBY QUARRY.

### Geological Section

*Thickness*

*UNIT 1 Verulam Formation* *6.0m*

Interbedded limestone and shale: medium to dark grey, weathers light grey; medium to coarse (rarely very coarse) crystalline limestone, laminae of very fine-crystalline limestone also present in shale; thin to medium bedded (5-15 cm), with shale beds 1-3 cm thick, sharp contacts, planar to slightly undulating; very fossiliferous with abundant brachiopods, trilobites, bryozoans, and crinoidal debris.

*Total thickness* *6.0m*

### REFERENCES

Goudge, 1938, p.126

### MAPS

Hewitt, 1964e, ODM Map 2053
Liberty, 1971d, GSC Map 17–1970

## NP–12 J.R. STOREY CONSTRUCTION LTD. — NAPANEE QUARRY

### LOCATION AND OWNERSHIP

J.R. Storey Construction Ltd. owns and operates this quarry in Lot 19, Concession 7, North Fredericksburgh Township, Lennox and Addington County, located on the eastern outskirts of Napanee, north of Highway 2 (Figure NP–12–1). The quarry has been expanded to include what was once known as H.J. McFarland's Napanee Quarry (Hewitt, 1964c, p. 33). The Storey family has operated the Napanee Quarry and adjacent North Fredericksburg Quarry since the turn of the century. This quarry is not in an area designated under the Pits and Quarries Control Act and has an area of 6.6 ha.

### GEOLOGY

The 16 m of strata in the quarry consist of predominantly thin–bedded limestone of the upper member, Gull River Formation. Most of the limestone is microcrystalline to very fine crystalline and only rarely do coarser–crystalline beds occur. Thin shale partings commonly occur between the limestone beds, especially in a 0.75 m thick interval in the uppermost unit in the quarry. Bedrock is overlain by up to 2 m of glacial overburden.

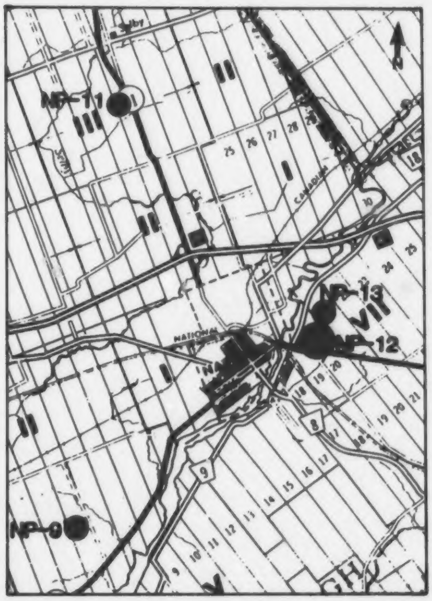


Figure NP–12–1. LOCATION MAP FOR NAPANEE QUARRY.

Photo NP-12-1. TEREX 7251 LOADER HAULING BLASTED ROCK TO CRUSHER; NAPANEE QUARRY (LOOKING SOUTH).

The quarry limestone possesses a very high lime content (38.8% CaO) and conversely, low magnesia (0.73% MgO) and silica contents (less than 0.1% $SiO_2$).

### Geological Section

| | | *Thickness* |
|---|---|---|
| *UNIT 3* | *Gull River Formation, upper member* | *5.7m* |

Limestone: dark to medium grey, weathers light to medium grey; microcrystalline to very fine crystalline; medium bedded (10-20 cm) with very thin shale partings common between most beds, uppermost bed 30 cm thick; 4.25 m above base of unit is a 0.75 m interval of thinner bedded, fine-crystalline limestone interbedded with thin-laminated, fissile, shaly limestone and shale; small calcite crystals common in most beds; fossiliferous with brachiopods and trilobites most abundant; lower contact of unit sharp and planar at base of lowest shale parting.

| | | |
|---|---|---|
| *UNIT 2* | *Gull River Formation, upper member* | *4.7m* |

Limestone: dark grey, weathering medium grey to light brown; microcrystalline to very fine crystalline; thin bedded (5-10 cm), with sharp, planar contacts; small calcite crystals common; moderately fossiliferous; west side of quarry at bedrock surface, with the surface rising to the southeast; lower contact of unit sharp and planar; top of the middle lift at top of unit.

| | | |
|---|---|---|
| *UNIT 1* | *Gull River Formation, upper member* | *5.6m* |

Limestone: dark grey, weathering medium grey; microcrystalline to very fine crystalline; thin to medium bedded (5-15 cm) in very regular beds with sharp and planar contacts, generally shale-free; small calcite crystals very abundant; sparsely fossiliferous; top of the lower lift at top of this unit.

| | |
|---|---|
| *Total thickness* | *16.0m* |

### QUARRY OPERATION

The quarry has been excavated into the crest of a northeast trending escarpment and the present working face is in the southwest corner. The complex lift pattern exposed in the quarry is the result of a long operating history and an uneven bedrock surface. Three primary lifts can be identified, totalling 16.0 m in thickness.

The first lift of 4.5 m has been completely extracted; a second lift of about 6.0 m is presently in production. Drilling and blasting is subcontracted; a drill pattern of 2.4 m x 2.4 m used with 7.6 cm diameter holes. Amex II (AN/FO) is used as a bulk explosive, primed with Forcite 75%, initiated with electric delay caps.

### PROCESSING

The blasted stone is loaded and transported by a Cat 988 loader to the portable crushing system. Primary crushing is by Cedarapids 30 in. x 42 in. double impeller crusher. A Terex 7251 4 yd. loader is used to handle stockpiling and loading of trucks.

### PRODUCTS

1 1/2 in. Clear Stone
3/4 in. Clear Stone
5/8 in. Crushed Rock
Agricultural Lime (produced at the Morven Quarry, NP-16)

### REFERENCES

Hewitt, 1960, p. 64
Hewitt, 1964a, p. 33

### MAPS

Hewitt, 1964e, OPM Map 2053
Liberty, 1971d, GSC Map 17-1970
Carson, 1981c, OGS Map P.2413

## NP-13 J.C. DENNISON — NAPANEE QUARRY

### LOCATION AND OWNERSHIP

J.C. Dennison operates this quarry on Lot 21, Concession 7, North Fredericksburgh Township, Lennox and Addington County (Figure NP-13-1). It is located on the north side of Highway 2, on the eastern outskirts of Napanee.

### GEOLOGY

The quarry consists of two lifts of thin-bedded, generally microrystalline limestone of the upper member of the Gull River Formation. At the time of the field work in 1986, the lower lift was partially filled with water and a total of 7.5 m of strata was exposed above the water level. Glacial overburden on the bedrock surface ranges from 1-2 m in thickness.

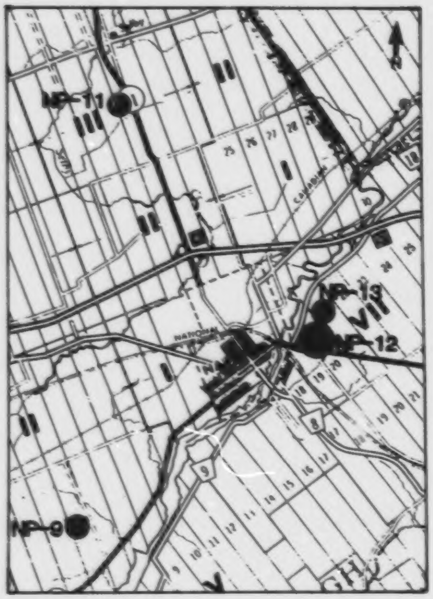


Figure NP-13-1. LOCATION MAP FOR NAPANEE QUARRY.

### Geological Section

| | Thickness |
|---|---|
| UNIT 1 Gull River Formation, upper member | 7.5m |

Limestone: dark grey, weathering medium grey; microcrystalline to very fine crystalline, with rare beds of fine crystalline; thin to medium bedded (5–15 cm), with sharp, planar contacts; thin shale partings usually present; 2.5 m above base of upper lift is a 0.7 m thick interval of thinner bedded limestone with more abundant and thicker shaly limestone and shale interbeds; small calcite crystals common; fossiliferous; top of the lower lift was 4.0 m below top of the quarry (3.5 m above the water level at the time of the field visit).

| Total thickness | 7.5m |
|---|---|

### CHEMICAL ANALYSES*

Components in Percent

| | | | |
|---|---|---|---|
| $SiO_2$ | 3.44 | CaO | 52.4 |
| $Al_2O_3$ | 0.76 | $P_2O_5$ | 0.04 |
| $Fe_2O_3$ | 0.40 | $SO_3$ | 0.48 |
| MgO | 0.60 | L.O.I. | 42.0 |
| | | Total | 100.1 |

* *after Hewitt and Vos, 1972, p. 21–22.*

### REFERENCES

Hewitt and Vos, 1972, p. 21–22

### MAPS

Hewitt, 1964e, OPM Map 2053
Liberty, 1971d, GSC Map 17–1970
Carson, 1981c, OGS Map P.2413

## NP-14 GRIFFIN BROTHERS (GANANOQUE) LTD. — DILLON QUARRY

### LOCATION AND OWNERSHIP

In 1980 this quarry was opened in the northern half of Lot 49, Concession 8, Camden East Township, Lennox and Addington County by Griffin Brothers (Gananoque) Ltd. (Figure NP–14–1). Stone crushed in this quarry is stockpiled in an old abandoned quarry across the road to the north, located in the southern half of Lot 49, Concession 9, Camden East Township.

### GEOLOGY

The 6.6 m face of the new quarry consists of limestones and dolostones of the lower member of the Gull River Formation. The lowest unit of green–grey dolostone grades upwards into a shaly dolostone. The remaining strata in the quarry consist of light grey, microcrystalline to very fine–crystalline limestone with uniform bedding of 10–15 cm which thickens to 50 cm at the top of the quarry. Glacial overburden around the quarry is generally less than 1 m thick.

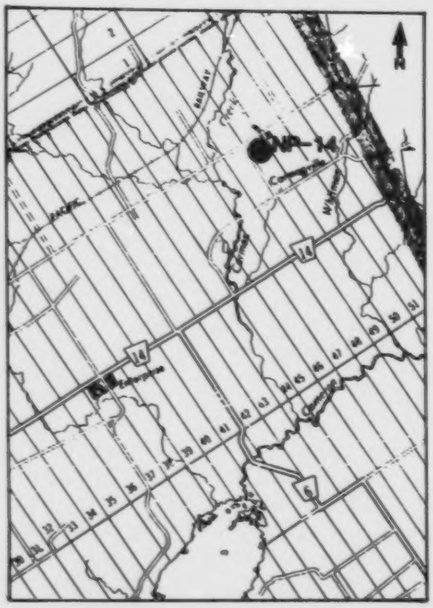


Figure NP-14-1. LOCATION MAP FOR DILLON QUARRY.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 3 Gull River Formation, lower member* | *4.5m* |

Limestone: light to medium grey, weathers light grey; microcrystalline, with some very fine crystalline intervals; thin bedded (5–10 cm) which thickens (to 50 cm) upwards, sharp and planar contacts; unfossiliferous; lower contact of unit sharp and planar.

| | |
|---|---|
| *UNIT 2 Gull River Formation, lower member* | *1.0m* |

Limestone: light grey, weathers same; very fine crystalline; medium bedded (10–15 cm), very uniform beds, with sharp, planar contacts; unfossiliferous; lower contact of unit sharp and planar.

| | |
|---|---|
| *UNIT 1 Gull River Formation, lower member* | *1.1m* |

Dolostone, grading upwards into shaly dolostone: light green-grey, weathers light green; fine crystalline; medium bedded (20–30 cm) with sharp, planar contacts, beds break down with weathering into 2–5 cm thick intervals with very irregular partings; upper part of unit weathers recessively.

| | |
|---|---|
| *Total thickness* | *6.6m* |

### REFERENCES

None

### MAPS

Liberty, 1971d, GSC Map 17–1970

Carson, 1981c, OGS Map P.2413

## NP–15 TOWNSHIP OF CAMDEN EAST — CAMDEN EAST QUARRY

### LOCATION AND OWNERSHIP

The Township of Camden East intermittently operates this quarry in Lot 26, Concession 2, Camden East Township, Lennox and Addington County (Figure NP–15–1). It is located on the eastern side of County Road 4, 2.5 km northwest of the village of Camden East. The area is not designated under the Pits and Quarries Control Act.

### GEOLOGY

The 7.0 m quarry face exposes limestone of the upper member of the Gull River Formation and the lower member of the overlying Bobcaygeon Formation. The lowest 4.2 m in the quarry consist of dark grey, microcrystalline to fine-crystalline, thin-bedded limestone. Some beds contain clusters of very small pyrite crystals, although no iron oxide staining was visible. The overlying 1.8 m consist of light brown, very fine-to fine-crystalline, thin-bedded limestone which weathers more recessively than the under- and overlying units.

The uppermost unit consists of two 0.5 m thick beds of light grey, microcrystalline limestone of the lower member, Bobcaygeon Formation. The upper bedrock surface exhibits a pitted appearance, and fractures and joints have been greatly enlarged by dissolution.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 3 Bobcaygeon Formation, lower member* | *1.0m* |

Limestone: light to medium grey, weathers light grey; microcrystalline; thick bedded (50 cm) with sharp stylolitic contacts; small patches of calcite crystals, "birdseye" texture, present; upper bedrock surface pitted, with fractures and joints enlarged by dissolution; lower contact of unit sharp and planar.

| | |
|---|---|
| *UNIT 2 Gull River Formation, upper member* | *1.8m* |

Limestone: light grey-brown to light brown, weathers medium brown; very fine to fine crystalline; thin bedded (5–10 cm), with sharp, planar contacts; unit weathers more recessively than other units; lower contact of unit sharp and planar.

| | |
|---|---|
| *UNIT 1 Gull River Formation, upper member* | *4.2m* |

Limestone: dark grey, weathers medium grey; microcrystalline to fine crystalline; thin bedded (5–10 cm) with sharp, planar, rarely stylolitic contacts; small clusters of very small pyrite crystals occur rarely, numerous small patches of calcite crystals, "birdseye" texture; fossiliferous.

| | |
|---|---|
| *Total thickness* | *7.0m* |

### REFERENCES

Parks, 1912, p.214–215

Hewitt, 1964a, p.29–30

Verschuren et al., 1985, p.50

### MAPS

Liberty, 1971d, GSC Map 17–1970

Carson, 1981c, OGS Map P.2413

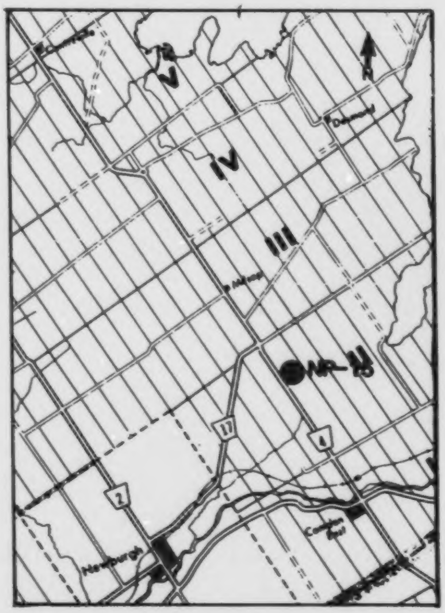


Figure NP-15-1. LOCATION MAP FOR CAMDEN EAST QUARRY.

## NP-16 J.R. STOREY CONSTRUCTION LTD. — MORVEN QUARRY

### LOCATION AND OWNERSHIP

J.R. Storey Construction Company owns and intermittently operates this recently opened quarry 10 km east of Napanee in Lot 9, Concession 5, Ernestown Township, Lennox and Addington County (Figure NP-16-1). The Morven Quarry is not designated under the Pits and Quarries Act and has an excavated area of 3 ha.

### GEOLOGY

The 4.2 m deep quarry exposes thin-bedded, shaly limestone of the upper member, Gull River Formation. The limestone is generally microcrystalline to very fine crystalline with a few beds of fine- to medium-grained calcarenite. Glacial overburden around the quarry is generally less than 1 m thick.

#### Geological Section

| | *Thickness* |
|---|---|
| *UNIT 1 Gull River Formation, upper member* | *4.2m* |

Limestone: dark grey to rarely grey-brown, weathers medium grey; microcrystalline to very fine crystalline, rarely fine- to medium-grained calcarenite; thin bedded (5-10 cm), with beds commonly separated by thin (less than 1.0 cm), dark grey, shale and shaly limestone partings; calcite-filled vugs occur sporadically in a few beds, small calcite crystals replacing fossils are common; moderately fossiliferous with brachiopods most common.

*Total thickness* *4.2m*

### QUARRY OPERATION

The limestone of the Morven Quarry is well-bedded and blasting produces a finely broken stone (-6 in). An "open" drilling pattern of 2.75 m x 3.7 m is used with 7.6 cm diameter holes.

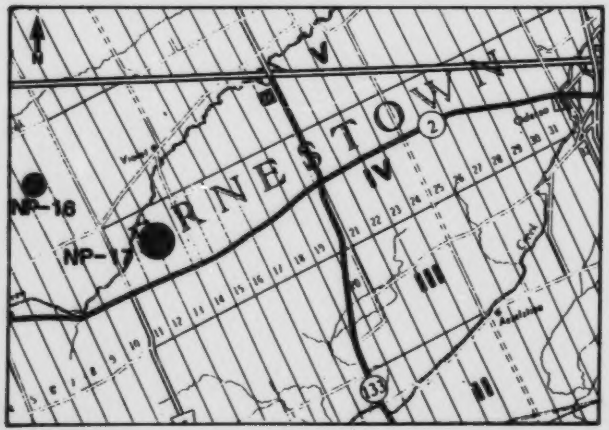


Figure NP-16-1. LOCATION MAP FOR MORVEN QUARRY.

### PROCESSING

The Morven stone is a good quality road base material. High quality limestone from the J.R. Storey Construction Ltd. Napanee Quarry (NP-12) is trucked to the Morven site for crushing and screening to produce agricultural lime.

### REFERENCES

None

### MAPS

None

## NP-17 J.C. DENISON — STORMS CORNERS QUARRY

### LOCATION AND OWNERSHIP

J.C. Denison owns and operates this recently opened quarry, 12 km east of Napanee in Lots 12-13, Concession 4, Ernestown Township, Lennox and Addington County (Figure NP-17-1). The quarry is not in an area designated under the Pits and Quarries Control Act.

### GEOLOGY

The quarry face exposes 10.0 m of the upper member of the Gull River Formation. The strata are characterized by thin-bedded microcrystalline to fine- crystalline limestone. Fossils occurring in these beds include large colonies of the coral *Tetradium*, other colonial corals, brachiopods, and crinoidal debris. Glacial overburden around the quarry is between 1 and 2 m thick.

#### Geological Section

| | *Thickness* |
|---|---|
| *UNIT 1 Gull River Formation, upper member* | *10.0m* |

Limestone: dark grey, weathers light to medium grey; microcrystalline to very fine crystalline, with some fine- to medium-grained calcarenite beds; thin bedded (5-10 cm), with thin (1 cm), dark grey shale and shaly limestone partings common between most limestone beds; small patches of calcite crystals common, "birdseye" texture; very fossiliferous, with large colonies of the coral *Tetradium* on the quarry floor and in lowermost 2 m, large colonial coral fragments, brachiopods, trilobites, and abundant crinoidal debris.

*Total thickness* *10.0m*

### REFERENCES

None

### MAPS

None

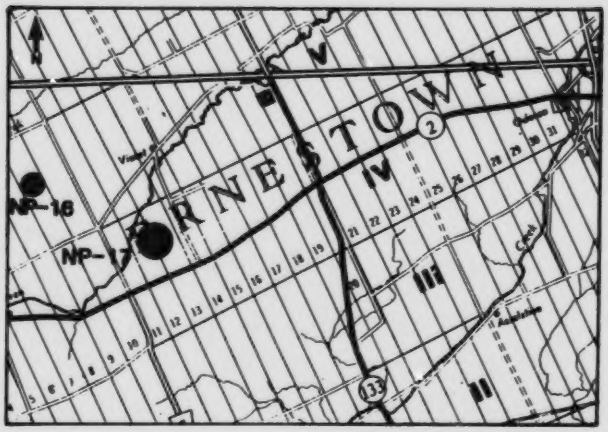


Figure NP-17-1. LOCATION MAP FOR STORMS CORNERS QUARRY.

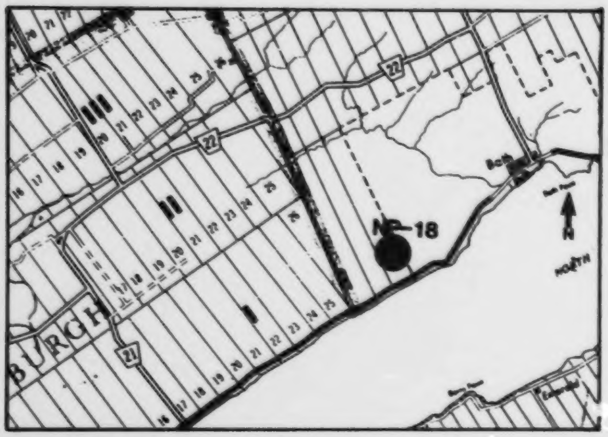


Figure NP-18-1. LOCATION MAP FOR BATH QUARRY AND PLANT.

## NP-18 LAFARGE CANADA INC. — BATH QUARRY AND PLANT

### LOCATION AND OWNERSHIP

Lafarge Canada Inc. began development of the Bath quarry and plant in 1970 with exploratory drilling of the site. The plant began operations in 1974. The quarry and plant are situated on the north side of Highway 33 approximately 2 km west of the Village of Bath in Lots 3 and 4, Concession I, Ernestown Township, Lennox and Addington County, as shown in Figure NP-18-1. The plant is serviced by road and rail (CN) transport and by a modern dock facility located on the shore of Lake Ontario immediately south of the plant.

### GEOLOGY

The quarry exposes an 18 m section of Middle Ordovician Verulam Formation limestone.

Exploration percussion and diamond drilling in 1970 by Lafarge tested the stratigraphy of the licence area. The analytical results from the chip and core samples, as shown in Table NP-18-1, are reported by Lafarge to be representative of the chemical composition of the underlying stratigraphy within the property.

The site is overlain by a veneer of glacial debris ranging in depth from approximately 1 m to 4.5 m and averaging 2 m. The Verulam Formation trends N50°E and dips to the south at about .3 m in 53 m. The Verulam Formation is characterized by dark grey, thin-bedded limestone with two horizons of dark grey, thin-bedded, argillaceous and siliceous limestone. The upper horizon

TABLE NP-18-1. DRILL HOLE ANALYSIS, 1970 DRILLING PROGRAM. CANADA CEMENT LAFARGE LIMITED, BATH QUARRY.

| | | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO | $SO_3$ | $K_2O$ | Loss | Total | SrO | $TiO_2$ | $P_2O_5$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Holes 1-35 incl. 61 m grid | Avg. | 8.75 | 2.76 | 1.09 | 46.61 | 1.73 | 0.96 | 0.59 | 38.03 | 100.52 | 0.10 | 0.09 | 0.07 |
| | Max. | 9.51 | 3.01 | 1.16 | 47.38 | 2.05 | 1.04 | 0.65 | 38.46 | 100.83 | 0.10 | 0.12 | 0.07 |
| | Min. | 8.22 | 2.60 | 0.98 | 46.04 | 1.39 | 0.82 | 0.54 | 37.46 | 100.28 | 0.09 | 0.07 | 0.06 |
| Holes 5,15,25, 35-57 incl., 59-61 incl., 63-69 incl. 122 m grid | Avg. | 8.69 | 2.71 | 1.07 | 46.71 | 1.73 | 0.95 | 0.55 | 38.04 | 100.45 | 0.10 | 0.08 | 0.07 |
| | Max. | 9.11 | 2.97 | 1.14 | 47.27 | 2.05 | 1.03 | 0.60 | 38.58 | 100.83 | 0.11 | 0.11 | 0.07 |
| | Min. | 8.27 | 2.52 | 1.03 | 46.28 | 1.12 | 0.84 | 0.51 | 37.30 | 99.85 | 0.09 | 0.06 | 0.06 |

*Notes: Samples for each hole were obtained by percussion drilling to 18 m depth.*

is up to 6 m thick and occurs in the middle of the quarry face at depths ranging from 6 m to 12 m. The lower horizon is approximately 3 m thick and occurs in the lower 3 m of the formation. The chlorine content is low on the quarry face, averaging about 0.026%, though it tends to increase into the face.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 1 Verulam Formation* | *17.7m* |
| Limestone with alternating shaly limestone and shale: medium to dark grey, weathers medium grey; limestone generally fine to medium crystalline, with some very fine-crystalline beds; limestone thin bedded (2-7 cm), shaly limestone and shale thin bedded (2-5 cm); small calcite crystals replacing fossils common; very fossiliferous with brachiopods, trilobites and crinoid debris most common. | |
| *Total thickness* | *17.7m* |

## QUARRY OPERATION

The quarry occupies an area of approximately 50 ha with a single bench of about 18 m in height. Drilling is done with a Gardner-Denver rotary drill using 150 mm diameter holes. Holes are drilled to the quarry floor. Drilling is conducted on a single line basis with 9 to 18 holes spaced 1.8 m apart. The blasting agent is AN/FO, which is mixed in the hole. The use of a premix blasting system is being examined. The typical blasting charge is 150 g/t. Rock shatter is excellent and no secondary blasting or breaking is required.

## PROCESSING

Loading of shattered rock is by two 12-yd. front-end loaders (Cat 992, Clark 975B) directly to the primary crusher, which is located on the quarry floor. Primary crushing is conducted by a Hazemag 887C, two rotor impact crusher producing -3 in. and -1 in. stone at a rate of 500 tonnes per hour. Crushed material is conveyed from the pit by a 500 m long, 42 in. belt and then transferred to a 1,000 tonne per hour Stephens-Adamson travelling stacker system located inside a large raw material and clinker storage building adjacent to the plant. Crushed limestone storage is approximately 25,000 tonnes.

At the time of the site visit, a small scale test program was being undertaken to determine the feasibility of removing the fines from the larger blasted material. A portable screening system was installed on the pit floor and selected portions of each blast were processed to remove small-sized material. Analysis indicated that the fines have a higher than average alkali content, which can cause problems with the refractories and alkali buildup in the electrostatic precipitators.

Silica is provided in the form of Hay Bay sand or Potsdam sandstone, the latter being ground in an autogenous ball mill. Sand is dried to 1% moisture content and then stored in a 1,000 ton concrete silo.

**Photo NP-18-1. EAST FACE OF BATH QUARRY.**

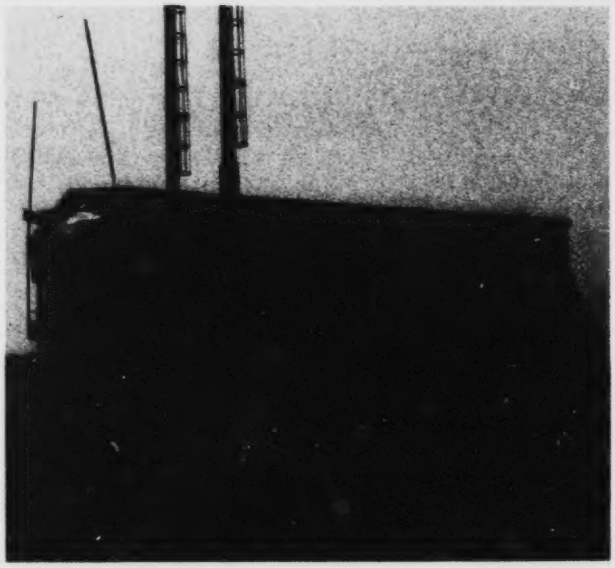


**Photo NP-18-2. HAZEMAG IMPACT CRUSHER AT BATH QUARRY.**

Fly ash, gypsum and anhydrite are stored in the open on the quarry floor and transported to raw mill feed storage by front-end loader. Previously, mill scale had been used as a source of iron but it was found that trace ele-

**Photo NP-18-3.**
**PORTABLE SCREEN SYSTEM FOR SEPARATION OF HIGH ALKALI FINES; BATH QUARRY.**

ments in the material were causing problems with the operation of the precipitator.

The raw mill is an F.L. Smidth 29.5 ft. x 16.5 ft. single compartment ball mill having a rated capacity of 320 short tons per hour. Silica is prepared in a 34 ft. 4 in. x 9 ft. 6 in., 2–compartment F.L. Smidth ball mill having a rated capacity of 22 short tons per hour. Limestone and sand are pneumatically conveyed to the ball mills from raw material storage by Stephens–Adamson stacker/reclaimers. The limestone reclaimer has a capacity of 500 tons per hour while the silica reclaimer has a capacity of 90 tons per hour.

Raw feed is pneumatically conveyed to two 51 ft. I.D. x 200 ft. high homogenizing towers each with a capacity of 5,000 tonnes. Sturtevant air classifiers are used to ensure homogenization of the raw mix.

## KILN

Raw feed is passed from the homogenizing towers to an F.L. Smidth single stage, four–compartment preheater tower by bucket elevator. The preheater is fitted with two gas conditioners and an electrostatic precipitator to remove particulates. The preheater heats the raw feed to 400°C when it enters the kiln.

The kiln is a coal–fired F.L. Smidth dry process type with dimensions of 19 ft. x 22 ft. x 650 ft. and a rated capacity of 1.1 million tonnes per year. Coal for the kiln is prepared in an ultramodern plant supplied by Kennedy Van Saun. Coal and delayed coke are stored in two 500 tonne storage tanks and fed to a 21 ft.6 in. x 11 ft. ball mill by means of a variable speed screw–type feeder. The capacity of the ball mill is 20 tonnes per hour. The coal is processed to 85% passing 200 mesh, with oversize being returned to the mill by means of a Sturtevant air classifier. Crushed coal is pneumatically conveyed through cyclones to a 6 tonne storage bin. From the storage bin the coal is fed to the kiln via an air lock and screw conveyor. The coal preparation plant is equipped with a nitrogen flooding system to prevent explosions.

Hot clinker is discharged to Lurgi gravel bed coolers and then carried by Aumund pan conveyor to hot clinker storage. Once cooled, the clinker is conveyed to the raw materials storage building where it is stacked by a 350 tonnes–per–hour Stephens–Adamson travelling stacker. There is stored capacity for approximately 100,000 tonnes of clinker.

Clinker is retrieved from storage by a 300 tonnes per hour Ameco reclaimer. Final grinding is carried out in two 2–compartment ball mills with dimensions of 13 ft. x 49 ft., and a capacity of 93 tonnes per hour each. The finish mills are in closed circuit with Sturtevant air classifiers. Gypsum and anhydrite in a 70:30 ratio are added to the clinker and represent approximately 3.5% of the finished cement, which is then pneumatically conveyed to six 4,500–tonne silos.

Finished cement is recovered from the storage silos and pneumatically conveyed for loading by airslides for road, rail and water shipment (70% of shipment volume is by water).

Process control for all sections of the cement plant is handled by a Foxboro Fox 1 digital system and a General Electric analog system.

## PRODUCTS

Normal Portland
High Early Strength Portland
Sulfate Resisting Portland
Low Heat of Hydration Portland
Masonry Cement

## REFERENCES

None

## MAPS

Carson, 1982a, OGS Map P. 2497

# NP-19 F.G. BEZANSON AND SON LTD. — WILTON QUARRY

## LOCATION AND OWNERSHIP

The Wilton Quarry, owned and operated by F.G. Bezanson and Son Ltd., is located in Lot 36, Concession 6, Ernestown Township, Lennox and Addington County, 1 km south of the village of Wilton (Figure NP-19-1). The quarry is not designated under the Pits and Quarries Control Act and was opened as a pit in 1975 to extract sand and gravel. The operation was subsequently deepened into the bedrock and produces aggregate for local road construction, primarily operating from May to November.

## GEOLOGY

The single lift of 11 m exposes thin-bedded limestone of the upper member of the Gull River Formation. The generally microcrystalline to very fine-crystalline limestone is rarely interbedded with thin beds of fine- to medium-crystalline limestone. A few thin, slightly dolomitic limestone beds in the lower 2 m of the quarry suggest that the top of the lower member of the Gull River Formation is just below the quarry floor. Glacial overburden at the top of the quarry is thin, although a considerable thickness of sand is present along the flank of the hill into which the quarry is excavated.

### Geological Section

| | | *Thickness* |
|---|---|---|
| *UNIT 1* | *Gull River Formation, upper member* | *11.0m* |

Limestone: medium to dark grey, weathers medium grey, light brown near the top of quarry; microcrystalline to very fine crystalline, with rare, thin beds of fine to medium crystalline; thin bedded (5–10 cm), generally with sharp, planar contacts, only rarely with thin shale partings; numerous small patches of calcite crystals, "birdseye" texture; moderately fossiliferous with brachiopods, corals, and trilobites present; basal 2 m has very thin interbeds of light green-grey, silty, slightly dolomitic, limestone beds.

| | |
|---|---|
| *Total thickness* | *11.0m* |

## QUARRY OPERATION

The quarry area is currently about 300 m x 300 m on a single lift of 11 m. A drill pattern of 2.4 m x 2.4 m is used with 7.6 cm diameter blast holes. Holes are loaded with AN/FO and initiated with electric caps.

## PROCESSING

Two Michigan 175 loaders transfer shot rock to Louisville and International (25-ton) diesel trucks for haulage (approximately 200 m) to the primary crusher. Primary crushing is performed by a Cedarapids 25 in. x 40 in. jaw, feeding a 42 in. Pulvamatic Roller secondary crusher. Michigan 175 and Terex 51 (4 yd.) loaders are used for stockpiling and loading of trucks.

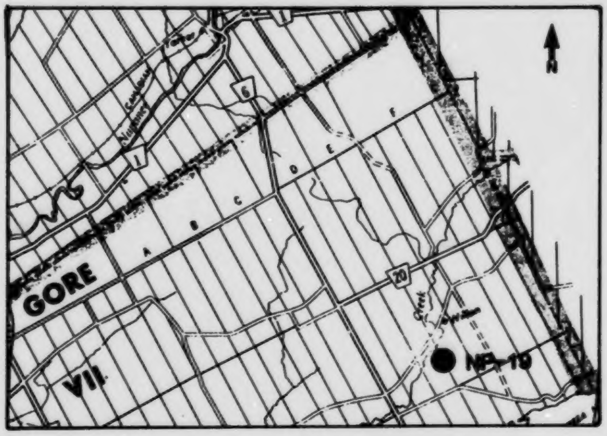


**Figure NP-19-1. LOCATION MAP FOR WILTON QUARRY.**

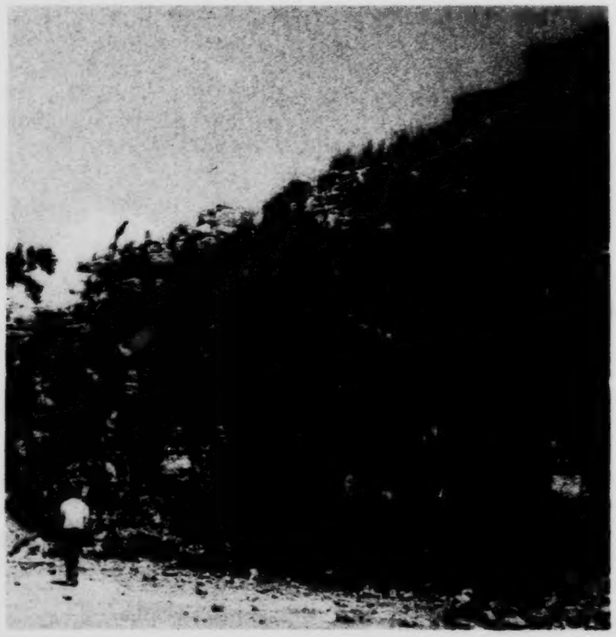


**Photo NP-19-1. TYPICAL SECTION AT WILTON QUARRY (LOOKING WEST).**

## PRODUCTS

4 in. Crusher Run
2 in. Crusher Run
Granular "A"
3/4 in. Clear Stone

3/8 in. Screenings
1/2 in. Chips

### REFERENCES

None

### MAPS

Carson, 1981c, OGS Map P.2413

## NP-20 TOWNSHIP OF AMHERST ISLAND — AMHERST ISLAND (CAUGHEY) QUARRY

### LOCATION AND OWNERSHIP

The quarry on Amherst Island is used intermittently as a source of crushed stone for local roads. It is located in the northeast quarter of Lot 9, North Shore Concession, Amherst Island Township, Lennox and Addington County, 2 km east of Stella (Figure NP-20-1). The quarry is not within an area designated under the Pits and Quarries Control Act.

### GEOLOGY

The quarry face exposes 9.3 m of interbedded limestone and shale of the Verulam Formation. The thin-bedded, fine- to medium-crystalline limestones are interbedded with coarse-crystalline bioclastic limestone beds. Two lifts are present; the top of the lowest lift is 4.3 m above the floor of the quarry. Glacial overburden around the quarry is thin.

### Geological Section

*Thickness*

*UNIT 1 Verulam Formation* *9.3m*

Limestone, interbedded with shaly limestone and shale: limestone - medium to dark grey to blue-grey on very fresh surfaces, weathers grey-brown to medium grey; fine to medium crystalline with rare beds coarse crystalline, bioclastic; thin-bedded (5-10 cm) with sharp, slightly undulating contacts; most beds very fossiliferous; shaly limestone and shale - medium to dark grey, weathers dark grey; in beds 2-5 cm thick which can weather into very fissile partings; beds commonly burrowed.

*Total thickness* *9.3m*

### REFERENCES

Verschuren et al., 1985, p47

### MAPS

Liberty, 1971a, GSC Map 19-1970
Carson, 1982a, OGS Map P.2497

## NP-21 PORTLAND TOWNSHIP (HARTINGTON) QUARRY

### LOCATION AND OWNERSHIP

The Township of Portland operates this quarry in Lot 3, Concession 7, Portland Township, Frontenac County, approximately 6 km northwest of Sydenham (Figure NP-21-1). The quarry is not designated under the Pits and Quarries Control Act.

### GEOLOGY

The 10.0 m deep quarry exposes limestones and dolostones of the lower member of the Gull River Formation. The limestone and dolostone alternate in units which vary from 0.5 to 1.0 m thick. The limestones are dominantly microcrystalline and medium bedded whereas the

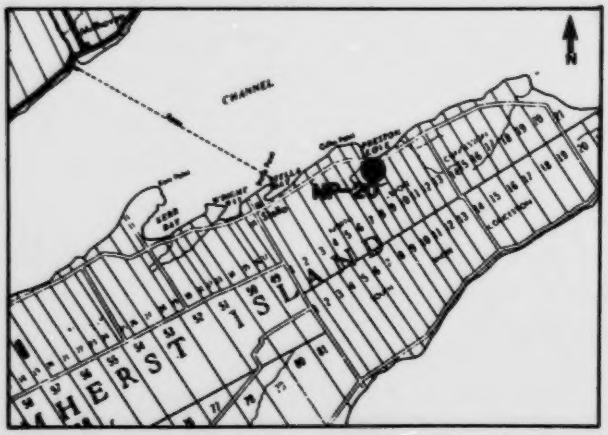


Figure NP-20-1. LOCATION MAP FOR AMHERST ISLAND (CAUGHEY) QUARRY.

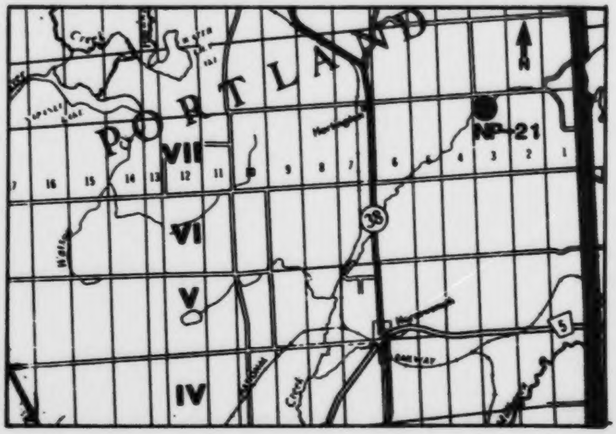


Figure NP-21-1. LOCATION MAP FOR PORTLAND TOWNSHIP (HARTINGTON) QUARRY.

dolostones are very fine crystalline and thin to medium bedded. The site had originally been excavated for sand, and up to 4 m of this material is present in the overburden.

### Geological Section

*Thickness*

*UNIT 1 Gull River Formation, lower member* *10.0m*

Alternating limestone and dolostone: limestone: light to dark grey, weathers light grey; microcrystalline to rarely very fine crystalline; medium bedded (20–30 cm), with sharp and planar contacts, in intervals 0.5–1.5 cm thick; uppermost bed in quarry 1.0 m thick;

dolostone: light green-grey; weathers light green-grey to light brown; very fine crystalline; thin to medium bedded (10–30 cm), with sharp and planar contacts, in intervals 0.5–1.0 m thick; small patches of calcite crystals present in some beds.

*Total thickness* *10.0m*

### CHEMICAL ANALYSES*

Components in Percent

| | | | |
|---|---|---|---|
| $SiO_2$ | 4.01 | CaO | 47.3 |
| $Al_2O_3$ | 2.30 | L.O.I. | 41.0 |
| $Fe_2O_3$ | 0.86 | Total | 99.55 |
| MgO | 4.08 | $CO_2$ | 40.5 |

* *after Hewitt and Vos, 1972, p. 38–39.*

### REFERENCES

Hewitt and Vos, 1972, p. 38–39.

### MAPS

None

## NP-22 W.J. McKENDRY AND SONS LIMITED — WESTBROOK QUARRY

### LOCATION AND OWNERSHIP

The Westbrook Quarry is located in Lots 6 and 7, Concession 2, Kingston Township, Frontenac County (Figure NP-22-1). The quarry is owned by Justice William Henderson and operated by W.J. McKendry and Sons Limited. The property is licensed for 12.2 ha. The Westbrook Quarry is one of three quarries operated by W.J. McKendry and Sons Limited in the Frontenac County area (see Glenburnie (NP-29) and Cranston (NP-26) quarries).

### GEOLOGY

The single quarry lift exposes 6.0 m of medium to dark grey, thin-bedded, microcrystalline to very fine-crystalline shaly limestone of the upper member of the Gull River Formation. A few thin beds of fine- to medium-grained calcarenitic limestone occur in the upper 2.5 m of the quarry. Glacial overburden around the quarry is less than 1 m thick.

### Geological Section

*Thickness*

*UNIT 1 Gull River Formation, upper member* *6.0m*

Limestone: medium to dark grey, weathers light grey, buff at top; microcrystalline to very fine crystalline, in upper 2.5 m rare beds of fine- to medium-grained calcarenites; thin to medium bedded (5–15 cm) with sharp, stylolitic contacts, or with thin, dark grey shale partings; small patches of calcite crystals, "birdseye" texture, very abundant; small pyrite crystals up to 2 mm occur rarely; moderately fossiliferous; 4.6 m above base of unit is 6 cm of dark grey, shaly limestone which weathers recessively.

*Total thickness* *6.0m*

### QUARRY OPERATION

A single 6.0 m lift is presently mined, and is planned to reach a depth of 9.8 m. A drill pattern of 2.1 m x 2.4 m is used with 7.6 cm holes. Amex II (AN/FO) is used as a bulk explosive and primed with 75% Forcite (40 mm x 200 mm) stick powder.

### PROCESSING

The rock is crushed with a portable system consisting of a Cedarapids 30 in. x 42 in. impeller primary crusher, with a 544 Commander crusher as a secondary unit. The crushing and screening are operated on a custom basis; a wide variety of stone sizes can be produced.

### PRODUCTS

Gabion Stone (+8 in., −12 in. coarse)
Gabion Stone (6 in. fine)
Rubble Rock
3 in. Crusher Run
5/8 in. Crusher Run
1/2 in. Crusher Run
3 in. Clear
1 in. Clear

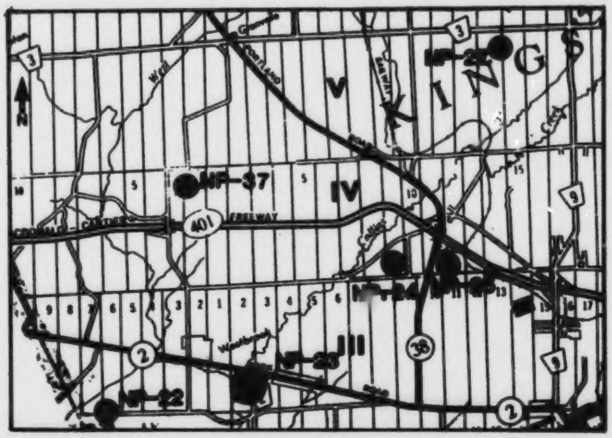
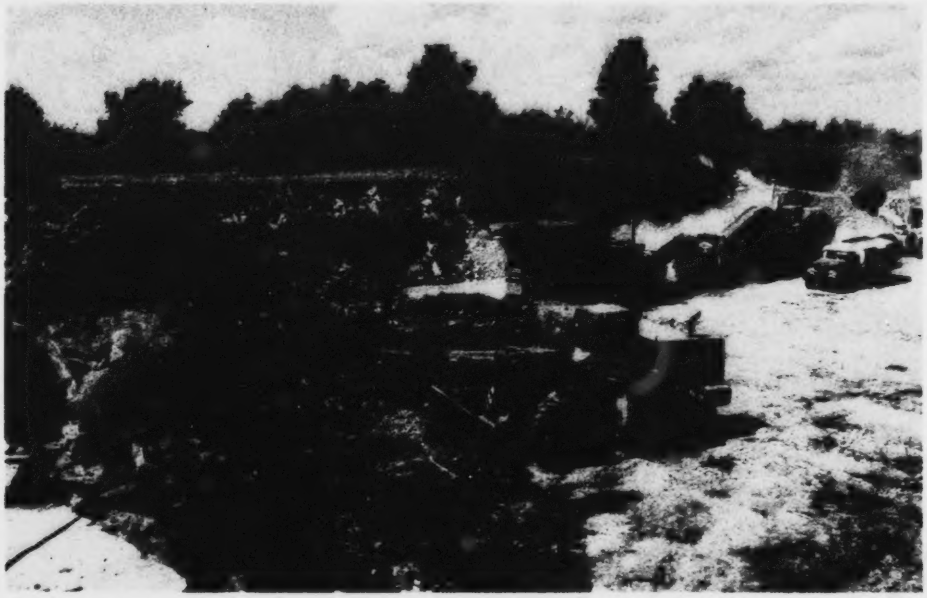


Figure NP-22-1. LOCATION MAP FOR WESTBROOK QUARRY.

**Photo NP-22-1.**
**175C CLARK LOADER AT FACE AND PORTABLE CRUSHER (BACKGROUND) AT WESTBROOK QUARRY (LOOKING NORTH).**



3/4 in. Clear
3/4 in. Concrete Stone
3/8 in. chips (concrete and asphalt grades)
Stone Dust

### REFERENCES

Hewitt, 1964a, p. 33

### MAPS

Liberty, 1971d, GSC Map 17–1970
Carson, 1981c, OGS Map P.2413

## NP–23 WOOD'S SAND AND GRAVEL LTD. – COLLINS BAY QUARRY

### LOCATION AND OWNERSHIP

This large quarry covers parts of Lots 2 and 3, Concession 3, Kingston Township, Frontenac County (Figure NP–23–1). It is located just south of Highway 2 on the west side of Collins Bay Road, approximately 2.5 km west of the Highway 38–Highway 2 interchange in Kingston. The quarry is owned and operated by Wood's Sand and Gravel and has been in operation since 1967. The quarry licence covers an area of 7.1 ha.

### GEOLOGY

The quarry has been worked for several years into the side of a north– south trending hillside; because the bedrock surface rises to the east a complex lift pattern has developed. The four lifts in the quarry expose a total of 36 m of strata from the Gull River Formation (Figure NP–23–2).

The lower 26.1 m in the quarry consist of interbedded limestone and dolostone of the lower member. The thin– to medium–bedded limestones are dominantly microcrystalline to very fine crystalline whereas the medium– to thick–bedded dolostones are fine crystalline. The thin– to medium–bedded, shaly limestone of the upper 9.9 m in the quarry is assigned to the upper member of the Gull River Formation. Glacial overburden around the quarry is up to 2 m thick.

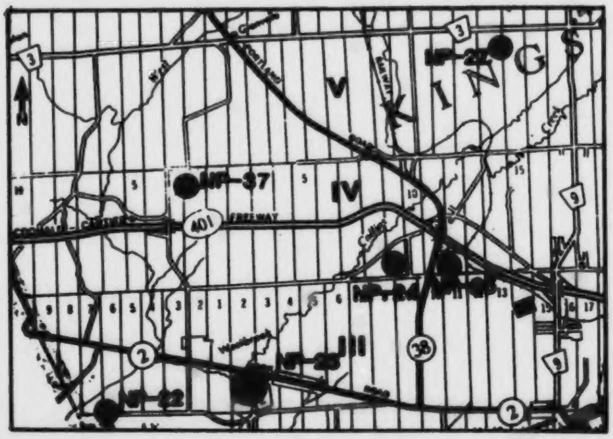


**Figure NP-23-1. LOCATION MAP FOR COLLINS BAY QUARRY.**

## Geological Section

| | *Thickness* |
|---|---|
| *UNIT 13 Gull River Formation, upper member* | *5.25m* |

Limestone: medium to dark grey, weathers light to dark grey, lowest 30 cm weathers nearly white; microcrystalline to very fine crystalline; medium bedded (10-30 cm) with sharp, stylolitic contacts or with very thin shale partings; large calcite-filled vugs very abundant in some beds, especially in beds 1.2 and 3.0 m above base of unit, pyrite crystals rarely present in a few beds; uppermost 0.5 m of quarry a single bed of light grey intraclastic limestone; lower contact of unit sharp and planar.

*UNIT 12 Gull River Formation, upper member* *0.15m*

Shaly limestone: very dark grey, weathers dark grey; very fine crystalline; thin laminated with even, parallel laminae; weathers recessively, makes a good marker; lower contact of unit sharp and planar.

*UNIT 11 Gull River Formation, upper member* *2.0m*

Limestone: medium grey, weathers same; microcrystalline; medium bedded (20-30 cm) with sharp, stylolitic contacts; most beds contain intraclasts of light grey, microcrystalline limestone; lower contact of unit sharp and planar.

*UNIT 10 Gull River Formation, upper member* *2.5m*

Limestone, with shaly limestone partings: medium grey, weathers light grey; most beds microcrystalline with some beds very fine crystalline; medium-bedded (25-30 cm) limestone, very thin-bedded (2-4 cm) shaly limestone interbeds; small patches of calcite crystals, "birdseye" texture, common in most beds; most beds are disrupted to some degree by deep mudcracks; lowest 25 cm of unit is a bed of dark grey limestone with light grey, microcrystalline intraclasts; lower contact of unit sharp and planar, at base of intraclastic conglomerate; top of third lift at top of unit.

*UNIT 9 Gull River Formation, lower member* *4.25m*

Interbedded limestone, dolostone and sandy dolostone with shaly limestone and shaly dolostone partings:

limestone - medium to dark grey, weathers medium grey; microcrystalline; medium bedded (15-25 cm); frequency of limestone beds increases in upper half of section;

dolostone - includes some partially dolomitized limestone; light grey to light green-grey, weathers light green-grey to light brown; very fine to fine crystalline;

thick bedded (30-70 cm) with thin shaly limestone or dolostone partings;

sandy dolostone - (only the interval from 2.25-3.25 m above base of unit) light green-grey, weathers green-grey to light brown; fine crystalline with about 2% coarse-grained, well-rounded quartz sand; massive on fresh surface, weathers into thin, rubbly partings at west end because it is at bedrock surface; unit exposed in entirety only in northeast corner of quarry; lower contact of unit sharp and planar, at base of 3-4 cm thick, dark grey, shaly limestone bed.

*UNIT 8 Gull River Formation, lower member* *7.1m*

Limestone: dark grey, weathers medium grey to grey- brown; microcrystalline to very fine crystalline; medium to thick bedded (10-40 cm) with sharp contacts, either stylolitic or very thin shale partings; very small patches of calcite crystals abundant, uppermost bed displays rusty brown surface stain although no obvious pyrite was observed; on west and southwest side of quarry this unit is at the top of the quarry due to the irregular bedrock surface, elsewhere in the quarry the top of this unit marks the top of the second lift; lower contact of unit sharp and planar.

*UNIT 7 Gull River Formation, lower member* *0.35m*

Dolomitic limestone: dark grey, weathers same; very fine to fine crystalline; one bed of 35 cm, with very faint thin laminae; contains very large (up to 20 cm diameter) calcite-filled vugs; both pink and white calcite occur, some vugs have open centres; lower contact of unit sharp and planar.

*UNIT 6 Gull River Formation, lower member* *5.4m*

Limestone: dark grey, weathers medium to dark grey; microcrystalline; apparently massive although irregular thin beds (5-10 cm) appear on some faces; small patches of calcite crystals rare; unit contains many fractures obscuring most bedding relationships; top of lowest lift is 1.6 m above the base of the unit, although this horizon varies because of irregularities in the height of the lower lift; lower contact of unit gradational over 2 cm, placed at base of lowest limestone bed.

*UNIT 5 Gull River Formation, lower member* *1.1m*

Sandy to muddy dolostone: light green to light grey-green, weathers light green to light grey; very fine crystalline with coarse-to very coarse-grained quartz sand grains; single bed; small patches of calcite crystals near base of unit; 20 cm above base of unit is a mottled, intraclastic conglomerate, containing gravel-sized clasts of dark grey, very fine-crystalline limestone; overlying 25 cm is light green, sandy dolostone with 10-15% coarse- to very coarse-grained, well-rounded quartz sand; balance of unit is a muddy dolostone, laminated in some intervals; lower contact of unit very sharp and abrupt.

*UNIT 4 Gull River Formation, lower member* *0.5m*

Limestone: dark grey, weathers same; microcrystalline to very fine crystalline; unit includes top of a bed and base of overlying bed, with the bedding plane subdividing this unit in half; lower 30 cm laminated with interlaminae of light grey, fine-crystalline dolostone; lower contact of unit sharp and planar at base of lowest limestone lamina.

*UNIT 3 Gull River Formation, lower member* *2.55m*

Dolostone: light green-grey to light grey, weathers light grey; very fine crystalline; massive bedded, with bedding planes 1.2-1.5 m apart, although beds weather into thinner layers; bedding plane contacts sharp and planar, except for one shaly dolostone interval 3 cm thick 0.9 m above base of unit: large calcite-filled vugs (up to 5 cm in diameter) commonly filled with pink calcite; lower contact of unit sharp and planar.

*UNIT 2 Gull River Formation, lower member* *3.45m*

Limestone: dark grey, weathers medium to dark grey; microcrystalline to very fine crystalline; thick bedded (30-60 cm), with sharp, planar, rarely stylolitic contacts; lower contact of unit sharp and planar, at 1 cm thick, recessive, dark grey shale interval.

*UNIT 1 Gull River Formation, lower member 1.4m*

Dolostone: light green-grey to light grey, weathers green-grey to light grey; very fine crystalline; medium bedded (20 cm), with very even beds, most thin laminated, and with sharp and planar contacts; 0.7 m above base of unit is a 30 cm thick bed of medium grey, microcrystalline limestone.

*Total thickness 36.0m*

## QUARRY OPERATION

The Collins Bay quarry has reached its mineable area limit of approximately 3 ha. The excavation is to a depth of 36 m on four lifts of 9 m, 6 m, 11 m and 10 m and a fifth lift of 10.5 m is projected for future production.

Drilling and blasting is performed by a subcontractor; a drill pattern of 2.7 m x 2.7 m is used with 7.6 cm diameter holes. Blast holes are column loaded with AN/FO (Nilite), primed with Tovex and initiated with electric delay caps. Due to a jointed seam structure of the rock the best blast fragmentation has been found to occur when using a choke blasting technique, where a "retaining wall" of previously blasted stone is left along the face during blasting

## PROCESSING

The blasted stone is transported by a Cat 966D (4.5 yd.), a distance of 50 m to 125 m to a portable crushing system. Primary crushing is by a Cedarapids 30 in. x 42 in. double impeller. The crushed stone (-3 in.) is fed into a surge hopper and can be sent for sorting by a Barber-Greene 4 ft. x 10 ft. double-deck screen, or drawn by chute as a Granular "B" product.

The screened products are -1 in (Granular "A"), -1 1/4 in. + 1 in. (3/4 in. clear) and -3 in. + 1 1/4 in. oversize that is sent to a Telsmith 3 ft. cone crusher for secondary treatment. The secondary crushed material is returned for screening. A Yale 2500 (4 yd.) loader is used for stockpiling and loading trucks.

## PRODUCTS

Rubble Rock
Granular "A" & "B"
3 in. Clear Stone
3/4 in. Clear Stone
Screenings
Top soil, sandfill and masonry sand.

## REFERENCES

Hewitt and Vos, 1972, p. 43-44

## MAPS

Liberty, 1971d, GSC Map 17-1970
Carson, 1981c, OGS Map P.2413

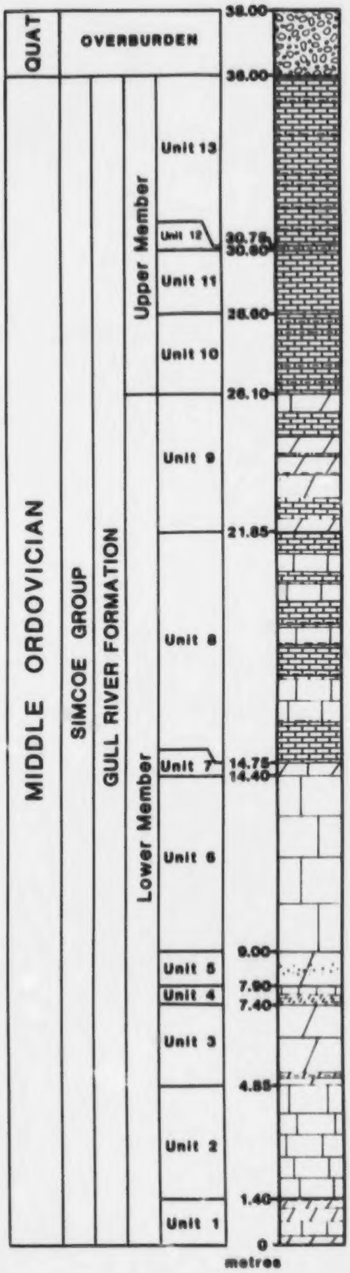

QUAT
OVERBURDEN
MIDDLE ORDOVICIAN
SIMCOE GROUP
GULL RIVER FORMATION
Upper Member
Lower Member
Unit 13
Unit 12
Unit 11
Unit 10
Unit 9
Unit 8
Unit 7
Unit 6
Unit 5
Unit 4
Unit 3
Unit 2
Unit 1
38.00
36.00
30.75
30.60
28.00
26.10
21.85
14.75
14.40
9.00
7.90
7.40
4.85
1.40
0
metres

Figure NP-23-2. STRATIGRAPHIC COLUMN FOR COLLINS BAY QUARRY.

Photo NP-23-1. CAT 966D LOADER FEEDING THE CEDARAPIDS PRIMARY CRUSHER; COLLINS BAY QUARRY.

## NP-24 H.J. McFARLAND CONSTRUCTION COMPANY — KINGSTON QUARRY

### LOCATION AND OWNERSHIP

The Kingston Quarry of H.J. McFarland Construction Co. is located west of the Highway 38 – Highway 401 interchange in Lot 9, Concession 4, Kingston Township, Frontenac County (Figure NP–24–1). This quarry was inactive at the time of the field work in 1986. The quarry licence covers an area of 8.5 ha.

### GEOLOGY

The quarry is 10.4 m deep and exposes limestones of the lower member of the Bobcaygeon Formation. Although the quarry face has weathered into thin–bedded limestone the original thick to massive bedding can still be identified, both in the quarry and in the roadcuts on the adjacent highways. The limestones are generally microcrystalline with some fine– to medium–crystalline and calcarenitic intervals present. Liberty (1971d) had assigned the rocks exposed in this quarry to Member D, Gull River Formation. Based upon the revisions by Williams (in prep.), these limestones are now assigned to the lower member of the Bobcaygeon Formation. The section exposed in this quarry is similar to that in the Kingston Quarry of the Township of Kingston (NP–25). Glacial overburden is generally thin around the quarry.

### CHEMICAL ANALYSIS*

Components in Percent

| | | | |
|---|---|---|---|
| $SiO_2$ | 4.29 | CaO | 51.2 |
| $Al_2O_3$ | 1.26 | $P_2O_5$ | 0.03 |
| $Fe_2O_3$ | 0.59 | $SO_3$ | 0.73 |
| MgO | 1.13 | L.O.I. | 41.0 |
| | | Total | 100.2 |

* *after Hewitt and Vos, 1972, p. 30–33.*

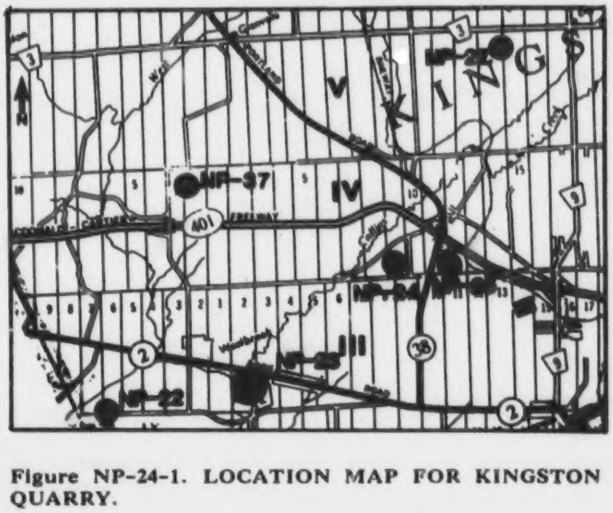


Figure NP-24-1. LOCATION MAP FOR KINGSTON QUARRY.

### REFERENCES

Hewitt and Vos, 1972, p. 30–33
Sabina, 1983, p. 6

### MAPS

Liberty, 1971d, GSC Map 17–1970
Carson, 1981c, OGS Map P.2143

## NP–25 TOWNSHIP OF KINGSTON — KINGSTON QUARRY

### LOCATION AND OWNERSHIP

This quarry, located in Lots 11 and 12, Concession 4, Kingston Township, Frontenac County just southeast of the Highway 38 – Highway 401 interchange, has been operated by the Township of Kingston as a source of aggregate (Figure NP–25–1). This quarry was inactive at the time of the field work in 1986. The quarry licence covers an area of 12.1 ha.

### GEOLOGY

The single lift exposes a 9.0 m face of limestones of the lower member of the Bobcaygeon Formation. These limestones are medium to dark grey, weather light to medium grey, and range from microcrystalline to fine crystalline. Original bedding in the quarry ranged from 0.5 to 1.5 m in thickness, but extensive weathering, and fracturing due to blasting have resulted in a thinner–bedded (5–10 cm) appearance. The thicker bedding can be seen in the adjacent roadcuts on Highway 401. Bedding plane contacts are sharp and slightly irregular due to stylolites, and no shale or shaly limestone is present. The assignment of these strata to the Bobcaygeon Formation is based upon revisions by Williams (in prep.) and differs from the previous work of Liberty (1971d) and Carson (1981c) who had assigned the strata in this quarry to the upper member of the Gull River Formation. Glacial overburden around the quarry is generally thin.

### CHEMICAL ANALYSIS*

Components in Percent

| | | | |
|---|---|---|---|
| $SiO_2$ | 3.46 | CaO | 51.5 |
| $Al_2O_3$ | 0.94 | $P_2O_5$ | 0.02 |
| $Fe_2O_3$ | 0.36 | $SO_3$ | 0.34 |
| MgO | 0.96 | L.O.I. | 41.8 |
| | | Total | 99.4 |

* *after Hewitt and Vos, 1972, p. 36–37.*

### REFERENCES

Hewitt and Vos, 1972, p. 36–37

### MAPS

Liberty, 1971d, GSC Map 17–1970
Carson, 1981c, OGS Map P.2413

## NP–26 W.J. McKENDRY AND SONS LTD. — CRANSTON (KEPLER) QUARRY

### LOCATION AND OWNERSHIP

This quarry is located approximately 1 km north of Kepler on Sydenham Road, in Lot 6, Concession 1, Loughborough Township, Frontenac County (Figure NP–26–1). The quarry is outside the area designated under the Pits and Quarries Control Act. The Cranston property covers 18 ha and was purchased in 1978 by W.J. McKendry and Sons Ltd.

### GEOLOGY

The 9.0 m deep quarry exposes alternating intervals of limestone and dolostone of the lower member of the Gull

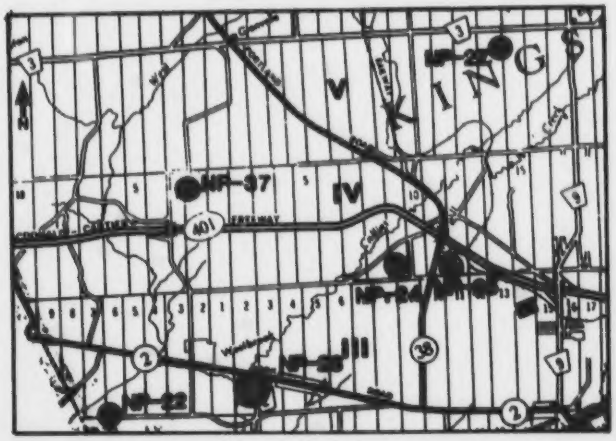


**Figure NP-25-1. LOCATION MAP FOR KINGSTON QUARRY.**

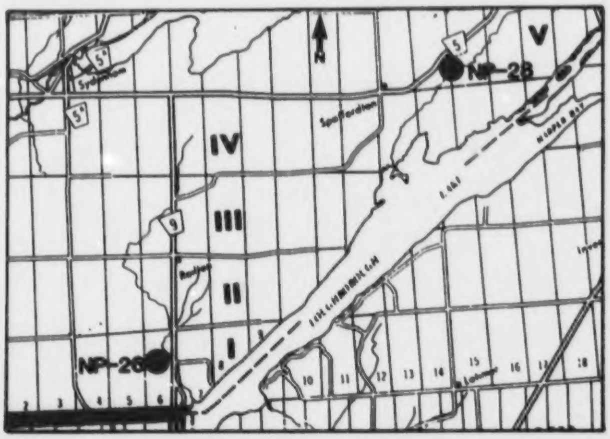


**Figure NP-26-1. LOCATION MAP FOR CRANSTON (KEPLER) QUARRY.**

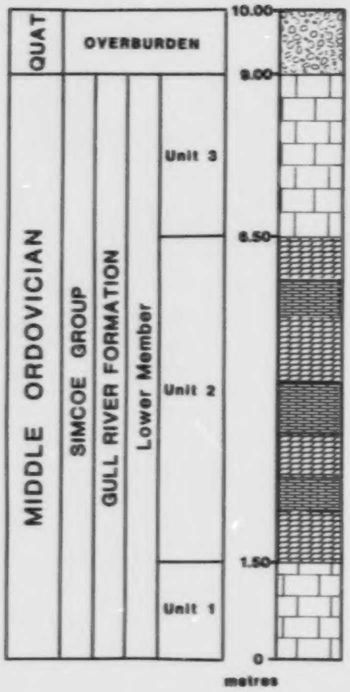


Figure NP-26-2. STRATIGRAPHIC COLUMN FOR CRANSTON (KEPLER) QUARRY.

River Formation (Figure NP-26-2). The limestones are generally microcrystalline and range from thin to thick bedded. The dolostones are generally fine crystalline and thin bedded. Glacial overburden overlying the bedrock surface reaches 1 m in thickness.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 3 Gull River Formation, lower member* | *2.5m* |

Limestone: dark grey, weathers light to medium grey; microcrystalline to rarely very fine crystalline; thick bedded (30-60 cm), though weathered surfaces exhibit a thin bedded appearance, sharp and planar contacts; sparsely fossiliferous; small patches of calcite crystals common; rarely intraformational conglomerates occur, with small clasts of light brown silty, dolomitic limestone in a matrix of microcrystalline limestone; lower contact of unit sharp and planar at base of lowest limestone bed.

| | |
|---|---|
| *UNIT 2 Gull River Formation, lower member* | *5.0m* |

Interbedded limestone and dolostone: limestone - light grey brown to medium grey, weathers buff to light grey; microcrystalline; thin bedded (5-10 cm), with sharp and planar contacts, small patches of calcite crystals present; dolostone - light brown to light green-grey, weathers medium brown to green-brown; very fine to fine crystalline; thin bedded (5-10 cm), with sharp and planar contacts; some silty and shaly dolostone beds also present; lower contact of unit sharp and planar base of lowest dolostone bed.

| | |
|---|---|
| *UNIT 1 Gull River Formation, lower member* | *1.5m* |

Limestone: dark grey, weathers medium grey; microcrystalline, with rare fine-crystalline beds; thick bedded (30-40 cm), which commonly breaks down into thin beds (5-10 cm), sharp contacts that range from planar to irregular.

| | |
|---|---|
| *Total thickness* | *9.0m* |

### QUARRY OPERATION

The Cranston Quarry is in the early stages of development and primarily supplied Granular products in 1986. A single 9.1 m lift is currently mined. The property represents a reserve of several million tonnes of aggregate.

### REFERENCES

None

### MAPS

Carson, 1981c, OGS Map P.2413.

## NP-27 FRONTENAC AGGREGATES AND CONSTRUCTION — ELGINBURG QUARRY

### LOCATION AND OWNERSHIP

The property is located in Lots 14 and 15, Concession 5, Kingston Township, Frontenac County, 1 km west of Elginburg (Figure NP-27-1). The Elginburg quarry was purchased in 1965 by McGinnis & O'Connor Limited and was opened by the same in 1970. The property is now owned and operated by Frontenac Aggregates and Construction, a division of Cruickshank Construction Ltd. The quarry is licensed for an area of 56.9 ha.

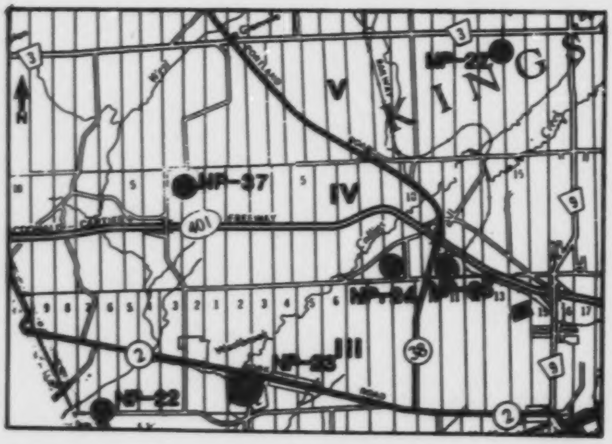


Figure NP-27-1. LOCATION MAP FOR ELGINBURG QUARRY.

**Photo NP-27-1. VIEW OF ELGINBURG QUARRY (LOOKING WEST).**

## GEOLOGY

The quarry is 10 m deep and exposes thin-bedded limestones of the upper member of the Gull River Formation. The limestones vary from microcrystalline to medium-grained calcarenites, although the calcarenites occur only sporadically. Shale partings are common between most limestone beds. Overburden thickness can vary from a few centimetres to about 3 m.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 1 Gull River Formation, upper member* | *10.0m* |
| Limestone: dark grey, weathers medium grey; microcrystalline to very fine crystalline, with sporadic beds of fine- to medium- grained calcarenites; thin bedded (5-10 cm) with thinner and thicker beds occurring, contacts sharp, ranging from planar to slightly irregular, commonly with thin shale partings; moderately fossiliferous. | |
| *Total thickness* | *10.0m* |

## CHEMICAL ANALYSIS*

**Components in Percent**

| | | | |
|---|---|---|---|
| $SiO_2$ | 4.43 | CaO | 50.4 |
| $Al_2O_3$ | 1.70 | L.O.I. | 40.8 |
| $Fe_2O_3$ | 0.74 | Total | 99.26 |
| MgO | 1.19 | $CO_2$ | 40.9 |

* *after Hewitt and Vos, 1972, p. 34-35.*

## QUARRY OPERATION

The excavated area of the quarry is about 4 ha and a single lift of 6.0 m to 9.1 m is worked. Overburden is stockpiled for rehabilitation of worked out areas. Drilling equipment includes a Gardner-Denver 3100 airtrack and Sullair compressor. A 2.7 m x 2.7 m drilling pattern is used with 7.6 cm diameter holes.

## PROCESSING

Crushing is performed on site by an associated company, Glengary Aggregates & Concrete of Green Valley, Ontario.

A Terex 7290 (7 yd.) loader is used to transport blasted stone from the face to the portable crusher. Primary crushing is by a 36 in. x 45 in. Cedarapids double impeller crusher feeding a Cedarapids 855 Commander (jaw & roller) secondary crusher.

The crushed stone is screened to produce Granular "A" or "B", 3/4 in. and 1/2 in. clear stone. A Stedman 44 in. pulverizer is available for recrushing and processing of screenings to manufacture a sand product.

## PRODUCTS

Granular "A" & "B"
3/4 in. Clear Stone (concrete aggregate)
1/2 in. Clear Stone
Screenings
Manufactured Sand

## REFERENCES

Liberty, 1971c, p. 9
Hewitt and Vos, 1972, p. 34-35

## MAPS

Liberty, 1971d, GSC Map 17-1970
Carson, 1981c, OGS Map P.2413

## NP-28 SPAFFORDTON QUARRY

### LOCATION AND OWNERSHIP

This quarry, just east of Spaffordton, is operated by the Township of Loughborough as a source for aggregate (Figure NP-28-1). It is located in Lot 14, Concession 5, Loughborough Township, Frontenac County, approximately 6 km east of Sydenham and is outside the area designated under the Pits and Quarries Control Act.

### GEOLOGY

The 8.3 m deep quarry exposes alternating units of limestones and dolostones of the lower member of the Gull River Formation. The limestones are dominantly microcrystalline and occur in medium-bedded intervals, which range from 0.5 to 1.5 m in thickness. Most of the limestone is extensively burrowed, which produces a mottled appearance on some exposures. The fine-crystalline dolostones commonly contain significant amounts of mud and silt, and intraclasts of light grey, microcrystalline limestone are also present in some beds. The dolostones are thin to medium bedded and occur in intervals which range from 0.5 to 1.0 m in thickness. Glacial overburden around the quarry is thin.

#### Geological Section

| | Thickness |
|---|---|
| *UNIT 1 Gull River Formation, lower member* | *8.3m* |

**Alternating limestone and dolostone:**

**limestone - light to medium grey, rarely grey-brown, weathers light grey; microcrystalline to rarely very fine crystalline; medium bedded (10-15 cm) with sharp, planar to stylolitic contacts, in intervals of 0.5 to 1.5 m thick; beds extensively burrowed.**

**dolostone - dark brown to light green- brown, weathers buff to light grey-green; fine crystalline with beds containing terrigenous mud and silt commonly present; thin to medium bedded (5-20 cm), with sharp and planar contacts, in intervals 0.5 to 1.0 m thick; some beds contain intraclasts of light grey, microcrystalline limestone.**

| | |
|---|---|
| *Total thickness* | *8.3m* |

### REFERENCES

None

### MAPS

Hewitt, 1964d, ODM Map 2054
Liberty, 1971d, GSC Map 17-1970
Carson, 1981c, OGS Map P.2413

## NP-29 W.J. McKENDRY AND SONS LIMITED — GLENBURNIE (KINGSTON) QUARRY

### LOCATION AND OWNERSHIP

The Glenburnie Quarry is located in Lot 25, Concession 5, Kingston Township, Frontenac County, 4 km north of Highway 401 on Division Street (Figure NP-29-1). The quarry has been in operation since the mid-1960s and is currently owned and operated by W. J. McKendry and Sons Limited. The original property licence, issued in 1972, was for 8 ha, to which a further 16 ha were added under a second licence in 1980.

### GEOLOGY

The quarry is 15.9 m deep and exposes strata of both the lower and upper members of the Gull River Formation (Figure NP-29-2). Dolostones and limestones of the lower member extend 8.9 m above the floor and are overlain by 7.0 m of shaly limestones of the upper member. The irregular bedrock surface is covered by up to 1 m of glacial overburden.

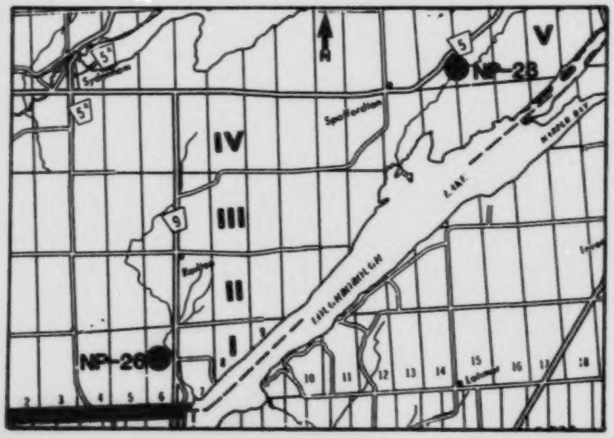


**Figure NP-28-1. LOCATION MAP FOR SPAFFORDTON QUARRY.**

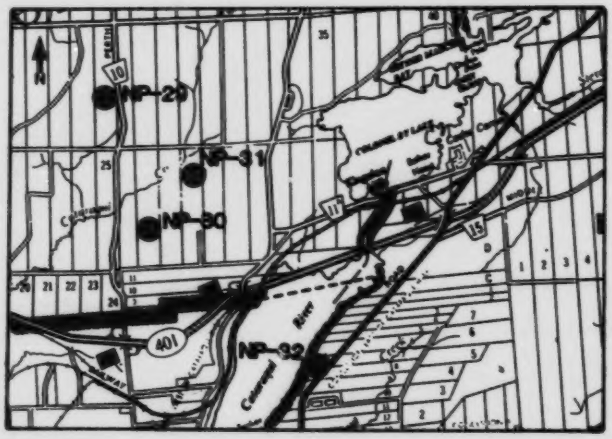


**Figure 29-1-1. LOCATION MAP FOR GLENBURNIE (KINGSTON) QUARRY.**

Photo NP-29-1.
PORTABLE CRUSHING AND SCREENING PLANT (LOOKING NORTHWEST); GLENBURNIE (KINGSTON) QUARRY.

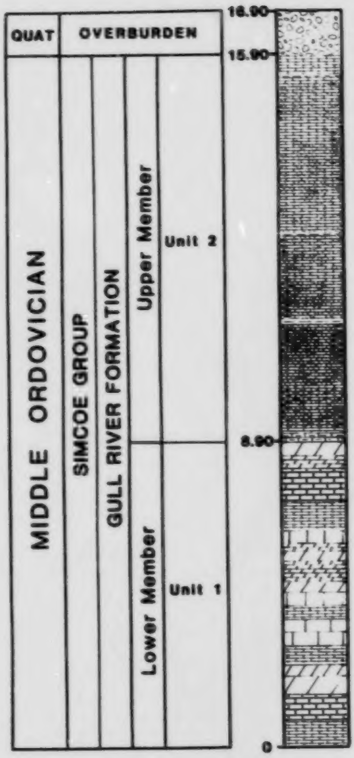


Figure NP-29-2. STRATIGRAPHIC COLUMN FOR GLENBURNIE (KINGSTON) QUARRY.

**Geological Section**

| | | *Thickness* |
|---|---|---|
| *UNIT 2* | *Gull River Formation, upper member* | *8.9m* |

Limestone, shaly: grey-brown to medium grey, weathers light to medium grey; microcrystalline to very fine crystalline; thin bedded (5-8 cm), with beds commonly separated by thin shale partings, some up to 2 cm thick; small calcite crystals common; moderately fossiliferous; lower contact of unit sharp and planar at base of lowest shale parting, coincident with the top of uppermost dolostone bed.

| | | |
|---|---|---|
| *UNIT 1* | *Gull River Formation, lower member* | *7.0m* |

Interbedded limestone and dolostone;

limestone - light grey to light brown, weathers light grey; microcrystalline with rare beds of fine crystalline; thin to medium bedded (5-15 cm), in intervals 1 to 2 m thick; sparsely fossiliferous;

dolostone - light brown to light green, weathers light green-grey to grey-brown to brown; fine crystalline with muddy, silty and sandy intervals; thin partings to medium bedded (less than 1-20 cm), in intervals less than 1 cm to 1.5 m thick; clusters of calcite crystals common.

*Total thickness* *15.9m*

## QUARRY OPERATION

Currently all stone is extracted from the western property (16 ha) on a single 10.6 m to 12.1 m lift. A second 6 m lift was taken on an experimental basis during the winter of 1985; results proved promising for future development.

Drilling equipment includes a Gardner-Denver 3100 air track (PR 123 Hammer) and 750 cfm compressor. A 2.1 m x 2.4 m drill pattern is used with 7.6 cm diameter holes. Amex II (AN/FO) is used as a bulk explosive and primed with 75% Forcite stick powder (40 mm x 200 mm). The blast holes are bottom capped with short period delays using electric delay caps.

## PROCESSING

W.J. McKendry and Sons Limited supply aggregate products to the Kingston area with a fleet of 3 tractor–

trailers, 6 tandem and 6 tri–axle trucks. A portable crushing system is set up on the site with a Cedarapids 30 in. x 42 in. jaw and a 543 Commander plant. The Commander plant contains a 4 ft. x 12 ft. internal screen and jaw and roller crushers that produce Granular "A". A second portable system consisting of a Cedarapids 30 in. x 42 in. impeller primary and a 544 Commander crusher is used at the Westbrook Quarry (NP–22) for custom crushing.

### PRODUCTS

Gabion stone (8 in. x 12 in., coarse)
Gabion stone (6 in. fine)
Rubble Rock
3 in. Crusher Run
5/8 in. Crusher Run
1/2 in. Crusher Run
3 in. Clear stone
1 in. Clear stone
3/4 in. Clear stone
3/4 in. Concrete stone
3/8 in. chips, concrete and asphalt grades
Stone dust

### REFERENCES

Hewitt, 1964a, p. 26
Hewitt and Vos, 1972, p. 36–37

### MAPS

Liberty, 1971d, GSC Map 17–1970
Carson, 1981c, OGS Map P.2413

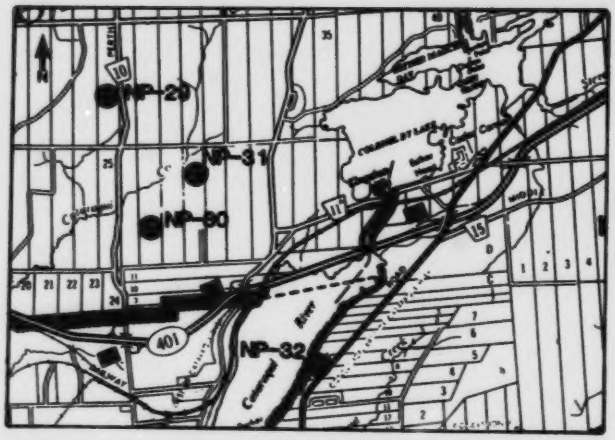
## NP-30 WOOD'S SAND AND GRAVEL LIMITED — MACADOOS LANE (GLEN LAWRENCE) QUARRY

### LOCATION AND OWNERSHIP

The Macadoos Lane Quarry, owned and operated by Wood's Sand and Gravel Limited, is located on Macadoos Lane, east of Division Street in Lots 26 and 27, Concession 4, Kingston Township, Frontenac County (Figure NP–30–1). The quarry was formerly owned by Glen Lawrence Construction Company. The quarry licence covers an area of 24 ha.

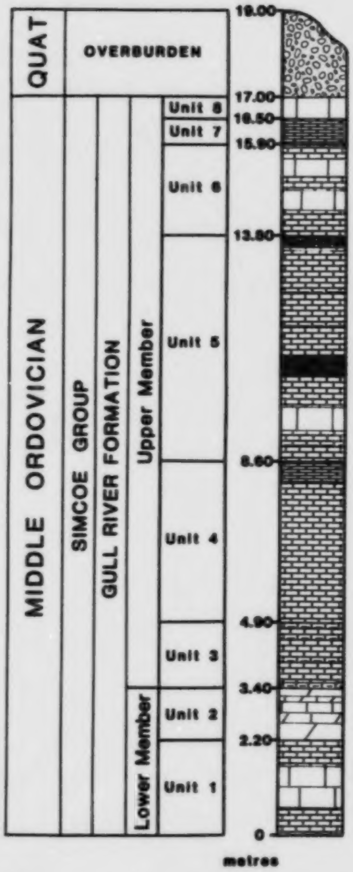
### GEOLOGY

Excavation of the quarry eastward into a hillside has exposed 17.0 m of limestone from the lower and upper members of the Gull River Formation (Figure NP–30–2). The lower lift consists primarily of interbedded limestone and dolostone of the lower member, whereas the overlying strata in the upper lift is assigned to the upper member of the Gull River Formation. The bedrock surface around the quarry rises to the east which results in the quarry face increasing in height from 5 to 17 m. The



NP-29
NP-31
NP-30
NP-32
10
15
17
401
Cataraqui River

Figure NP-30-1. LOCATION MAP FOR MACADOOS LANE (GLEN LAWRENCE) QUARRY.



QUAT
OVERBURDEN
MIDDLE ORDOVICIAN
SIMCOE GROUP
GULL RIVER FORMATION
Upper Member
Lower Member
Unit 8
Unit 7
Unit 6
Unit 5
Unit 4
Unit 3
Unit 2
Unit 1
19.00
17.00
16.50
15.90
13.80
8.60
4.90
3.40
2.20
0
metres

Figure NP-30-2. STRATIGRAPHIC COLUMN FOR MACADOOS LANE (GLEN LAWRENCE) QUARRY.

glacial overburden around the quarry ranges from 1–2 m in thickness.

### Geological Section

*Thickness*

*UNIT 8 Gull River Formation, upper member* *0.5m*

Limestone: dark grey, weathers light grey; microcrystalline; one bed 50 cm thick; small patches of calcite crystals, "birdseye" texture, present; upper surface not deeply weathered; lower contact of unit sharp and planar.

*UNIT 7 Gull River Formation, upper member* *0.6m*

Limestone: dark grey, weathers light grey-brown to light brown; microcrystalline; thin bedded (2–5 cm) with beds thinly laminated, often producing a shaly limestone upon weathering, sharp and planar contacts, lower contact of unit sharp and planar.

*UNIT 6 Gull River Formation, upper member* *2.1m*

Limestone: medium to dark grey, weathers light grey; microcrystalline to very fine crystalline; medium to thick bedded (20–40 cm), with sharp and planar contacts (no shale partings); large calcite-filled vugs common, as are small patches of calcite crystals, "birdseye" texture; lower 50 cm consists of an intraformational limestone conglomerate with very light grey, microcrystalline limestone intraclasts in a matrix of darker grey very fine-crystalline limestone; overall the crystallinity in the unit decreases in size upwards; lower contact of unit sharp and planar.

*UNIT 5 Gull River Formation, upper member* *5.2m*

Limestone: medium to dark grey, weathers light grey; microcrystalline to very fine crystalline; medium bedded (20–30 cm) with sharp, planar to rarely stylolitic contacts, very thin shale partings also occur; small patches of calcite crystals, "birdseye" texture, very abundant; some beds display deep, penetrative mud cracks; at 1.35 m above base of unit is a single 1.0 m thick bed of microcrystalline limestone, at both 2.5 m and 5.15 m above base of unit are 10 cm beds of dark grey, thinly laminated, shaly limestone; lower contact of unit sharp and planar.

*UNIT 4 Gull River Formation, upper member* *3.7m*

Limestone: dark grey, weathering light to medium grey; microcrystalline; medium bedded (20–30 cm), upper 0.5 m more thinly bedded (2–5 cm), sharp contacts with only rare, thin shale partings; small patches of calcite crystals, "birdseye" texture, common; upper part of unit weathers more recessively due to thinner bedding; lower contact of unit sharp and planar.

*UNIT 3 Gull River Formation, upper member* *1.5m*

Limestone: dark grey, weathers medium grey (to light brown at northwest corner of quarry because it is at surface); microcrystalline to very fine crystalline; medium bedded (20–30 cm), with shale partings 2–4 cm thick between limestone beds; small patches of calcite crystals, "birdseye" texture, numerous in limestone beds, especially in upper part of unit; lower contact of unit sharp; top of lower lift occurs at top of this unit.

*UNIT 2 Gull River Formation, lower member* *1.2m*

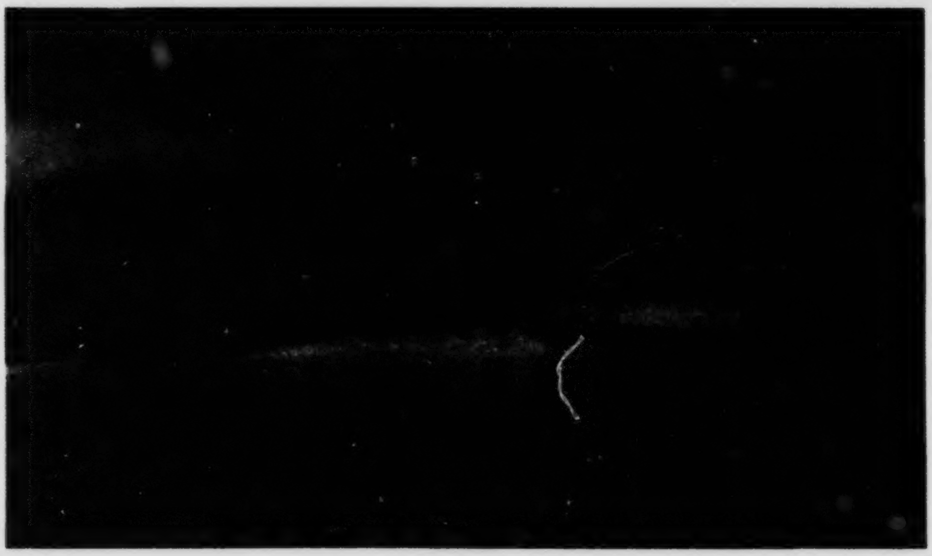
Dolostone, with dolomitic limestone and limestone interbeds: light to medium grey to green-grey, weathers light green-grey to light green; limestone is microcrystalline to very fine crystalline, dolostone is very fine to fine crystalline; massive, one bed; about 40% of unit consists of dolostone, with the remainder varying between limestone and dolomitic limestone; lower contact of unit sharp and planar.

*UNIT 1 Gull River Formation, lower member* *2.2m*

Limestone: dark grey, weathers same; microcrystalline, with rare beds of fine crystalline; medium to thick bedded (20–40 cm) bedded, with sharp planar contacts and rare, thin shale partings; small patches of calcite crystals, some of which are recrystallized brachiopod shells.

*Total thickness* *17.0m*

**Photo NP-30-1. PORTABLE CRUSHING PLANT AT MACADOOS LANE (GLEN LAWRENCE) QUARRY (LOOKING NORTHEAST).**



### QUARRY OPERATION

The excavated area of the quarry is about 12 ha worked in two lifts of 14 m and 6 m.

Drilling and blasting is subcontracted; a drill pattern of 3 m x 3 m is used with 7.6 cm diameter holes. Fragmentation is good due to the well bedded nature of the rock.

### PROCESSING

The blasted stone is transported approximately 100 m to 150 m by a Yale 3000 (4.5 yd.) loader to a portable crushing system. This consists of a Cedarapids 30 in. x 30 in. double impeller crusher in closed circuit with a 4 ft. x 10 ft. Parker double-deck screen. The screen products are -3/16 in. (screenings), -5/8 in. + 3/16 in., and +5/8 in. oversize to recrush.

### PRODUCTS

Rubble Rock
Granular "A" & "B"
-5/8 in. + 3/16 in.
Concrete Stone
Screenings

### REFERENCES

Liberty, 1971c, p. 9
Hewitt and Vos, 1972, p. 25-26

### MAPS

Carson, 1982c, OGS Map P.2496

## NP-31 H.J. McFARLAND CONSTRUCTION COMPANY— MACADOOS LANE (BILOW) QUARRY

### LOCATION AND OWNERSHIP

The Macadoos Lane Quarry of H.J. McFarland Construction Co. is located in Lot 29, Concession 4, Kingston Township, Frontenac County on the northern outskirts of the City of Kingston (Figure NP-31-1). The quarry was inactive at the time of the field work in 1986. The quarry licence covers an area of 13.0 ha.

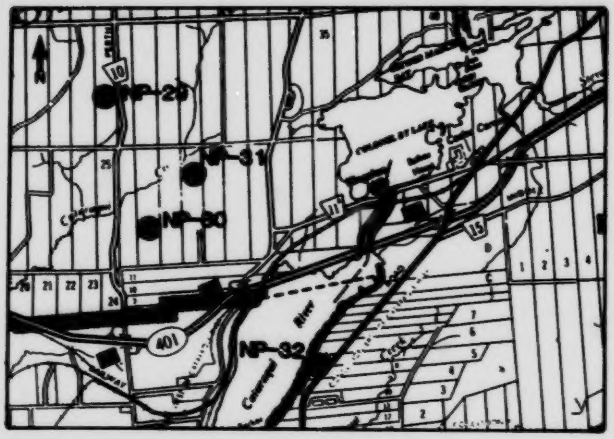


Figure NP-31-1. LOCATION MAP FOR MACADOOS LANE (BILOW) QUARRY.

### GEOLOGY

The quarry is split into two levels; the upper lift is stepped back from the lower because the bedrock surface rises gently to the south. The entire 9.35 m thick section consists of dark grey, microcrystalline to fine-crystalline, thin-bedded, shaly limestone of the upper member of the Gull River Formation. Shale partings are dark grey, commonly calcareous, and rarely exceed 1 cm in thickness. Some of the beds contain intraclasts of light grey, microcrystalline limestone. The crystal size in the limestone beds increases upward to the top of the quarry, becoming a fine-grained bioclastic calcarenite in the topmost metre, where the coral *Tetradium* is abundant. Glacial overburden around the quarry is generally less than 2 m thick.

### CHEMICAL ANALYSIS*

| | Components in Percent | |
|---|---|---|
| **Above Floor (m)** | **4.69 - 9.35** | **0 - 4.69** |
| $SiO_2$ | 3.44 | 8.20 |
| $Al_2O_3$ | 0.88 | 2.16 |
| $Fe_2O_3$ | 0.34 | 0.88 |
| MgO | 1.35 | 2.24 |
| CaO | 51.8 | 46.1 |
| $P_2O_5$ | 0.03 | 0.04 |
| $SO_3$ | 0.17 | 0.64 |
| L.O.I. | 42.5 | 38.7 |
| Total | 100.5 | 99.0 |

* *after Hewitt and Vos, 1972, p.17-18.*

### REFERENCES

Hewitt, 1964a, p. 36
Hewitt and Vos, 1972, p. 17-18

### MAPS

None

## NP-32 FRONTENAC AGGREGATES AND CONSTRUCTION — PITTSBURGH QUARRY

### LOCATION AND OWNERSHIP

The Pittsburgh Quarry is located on the east bank of the Cataraqui River, approximately 3.5 km north of the village of Barriefield (Figure NP-32-1). It extends across Lots 7 and 8, in the Concession East of the Cataraqui River, Pittsburgh Township, Frontenac County. This quarry was previously operated by McGinnis and O'Con-

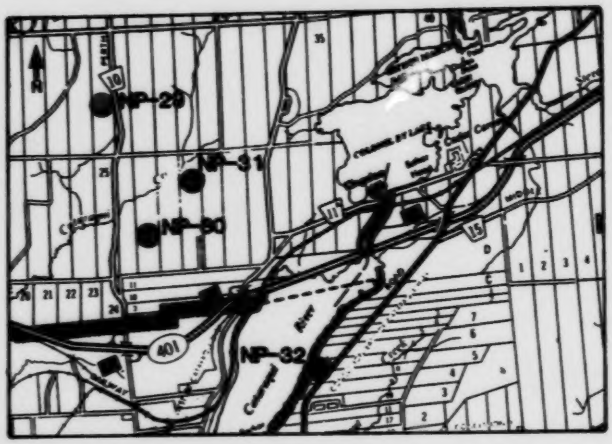

NP-29
NP-31
NP-30
NP-32
10
15
401
Cataraqui River

Figure NP-32-1. LOCATION MAP FOR PITTSBURGH QUARRY.

nor Limited, from 1949–1986, and was purchased in January 1986 by Frontenac Aggregates and Construction, the present operators. The quarry licence covers an area of 17.4 ha.

## GEOLOGY

The quarry exposes limestones and dolostones of the lower member of the Gull River Formation (Figure NP-32-2). The limestones and dolostones alternate in units generally 0.5 to 2.0 m thick. The dolostones in the lower part of the quarry are commonly silty or sandy, while some of those near the top of the quarry contain large calcite-filled vugs. Glacial overburden around the quarry is up to 2 m thick.

### Geological Section

*Thickness*

*UNIT 11 Gull River Formation, lower member* *2.2m*

**Dolomitic limestone:** light to medium grey, weathers light grey-brown to light brown at top of quarry; very fine crystalline; medium bedded (20–30 cm) with sharp and planar contacts; at the base and 1.0 m above base of unit are 1 cm thick shale partings which weather recessively; large (up to 20 cm diameter) calcite-filled vugs are prominent in some beds; lower contact of unit sharp and planar.

*UNIT 10 Gull River Formation, lower member* *1.1m*

**Limestone:** light to medium grey, weathers very light grey, almost white; microcrystalline; thick bedded (40 cm), although extensive fracturing obscures bedding in places, sharp and commonly stylolitic contacts; small patches of calcite crystals occur rarely; lower contact of unit sharp and planar.

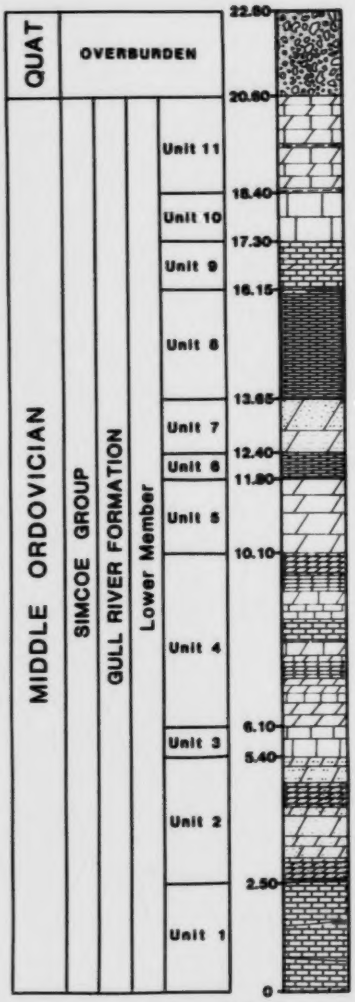

QUAT
OVERBURDEN
MIDDLE ORDOVICIAN
SIMCOE GROUP
GULL RIVER FORMATION
Lower Member
Unit 11
Unit 10
Unit 9
Unit 8
Unit 7
Unit 6
Unit 5
Unit 4
Unit 3
Unit 2
Unit 1
22.80
20.80
18.40
17.30
16.15
13.65
12.40
11.80
10.10
6.10
5.40
2.50
0
metres

Figure NP-32-2. STRATIGRAPHIC COLUMN FOR PITTSBURGH QUARRY.

*UNIT 9 Gull River Formation, lower member* *1.15m*

**Limestone:** in places dolomitic; medium grey, weathers medium to light grey-brown; very fine crystalline; medium bedded (20–30 cm), with sharp and planar contacts, some beds are thinly laminated; large (up to 15 cm diameter) calcite-filled vugs occur in uppermost bed of 25 cm; lower contact of unit sharp and planar.

*UNIT 8 Gull River Formation, lower member* *2.5m*

**Limestone:** medium to dark grey, weathers medium grey near base and lightens to nearly white at top of unit; microcrystalline, with a few beds very fine crystalline near base of unit; thin bedded (5–10 cm), in very even beds, sharp and planar contacts in lower part changing to stylolitic in upper part; small patches of calcite crystals occur rarely; lower contact of unit sharp and planar.

*UNIT 7 Gull River Formation, lower member 1.25m*

Dolostone, muddy to sandy: light green to light green-grey, (30 cm above base of unit very distinct medium green horizon), weathers light to dark green-grey; very fine crystalline, with mud to very coarse-grained sand intermixed; two beds - lower 35 cm and upper 90 cm; lower contact of unit gradational over 5 cm with laminae of dark grey limestone and light green dolostone.

*UNIT 6 Gull River Formation, lower member 0.6m*

Limestone: medium grey, weathers dark grey-brown; very fine crystalline; thin bedded (5-7 cm) with beds commonly laminated, sharp and planar contacts; unit prominently resistant to weathering; lower contact of unit sharp and abrupt.

*UNIT 5 Gull River Formation, lower member 1.7m*

Dolostone: light grey-brown, weathers light green-grey; very fine crystalline; thick bedded (80-90 cm), with sharp and slightly irregular contacts; faint laminae in some beds; numerous conchoidal fractures throughout unit; lower contact of unit very sharp and abrupt.

*UNIT 4 Gull River Formation, lower member 4.0m*

Dolomitic limestone, with interbeds of limestone and dolostone:

dolomitic limestone and dolostone - medium grey, weathers light green-grey to light grey; very fine crystalline; medium bedded, (15-35 cm), thin bedded (5-10 cm) in upper metre; patches of calcite crystals, up to 5 cm in diameter, present in some beds;

limestone - medium to dark grey, weathers light grey to grey-brown; microcrystalline; medium bedded (20-30 cm); lower contact of unit sharp and planar; top of unit is at top of second lift.

*UNIT 3 Gull River Formation, lower member 0.7m*

Limestone: medium to dark grey, weathers medium grey to light brown in uppermost 10 cm; very fine crystalline; medium bedded (30 cm); lower contact of unit sharp and planar; top of unit is at top of first (lowest) lift.

*UNIT 2 Gull River Formation, lower member 2.9m*

Dolostone, silty sandy: light grey to light green-grey, weathers same; very fine to fine crystalline; bedding variable, ranging from thin to thick bedded (10-80 cm), with sharp and planar contacts; lowest 40 cm is light green dolostone which displays extensive fractures and easily disintegrates into gravel; interval from 1.8 to 2.3 m above base of unit is a single bed of sandy dolostone in which very coarse to small pebble-sized quartz clasts make up 25% of the rock; the interval 2.3 to 2.5 m above the base of the unit is a distinctly laminated, dark grey, fine-crystalline, dolomitic limestone; lower contact of unit is sharp and irregular, with up to 20 cm of relief.

*UNIT 1 Gull River Formation, lower member 2.5m*

Limestone: dark grey, weathers medium to dark grey; microcrystalline to very fine crystalline; medium bedded (15-30 cm) with sharp, undulating to stylolitic contacts.

*Total thickness 20.6m*

## QUARRY OPERATION

The quarry has been developed over an area of about 10 ha. A total of 4 lifts have been established at heights of 6.7 m, 3.6 m, 6.7 m and 4.9 m; each lift is active with asphalt quality stone obtained from the 1st (top) and 3rd lifts and crusher run material from the 2nd and 4th (bottom) lifts. A drill pattern of 2.1 m x 2.1 m or 2.1 m x 2.4 m is used, 7.6 cm diameter holes being drilled with a Joy MS-4E air track and 750 cfm Jaeger compressor. The bottom lift of the quarry is approximately 2.0 m above the Cataraqui River, providing good natural drainage. From 18 to 30 holes are blasted each day using AN/FO (Nilite) as a bulk charge primed with Tovex 500 and initiated with electric delay caps.

## PROCESSING

The blasted stone is loaded by a 745-HB (5 yd.) Fiat-Allis loader into one of two 20-ton Terex haulage trucks. Primary crushing is by a Missouri Rogers 25 in. x 40 in. jaw crusher. The crushed stone (-6 in.) is then passed over a Kennedy Van Saun vibrating screen to remove -1 in. fines, and the -6 in. + 1 in. material is sent for secondary crushing by a Cedarapids 30 in. x 20 in. impeller crusher. The secondary crushed material is combined with the -1 in. fines and screened by a Cedarapids 42 in. x 10 ft. horizontal two-deck screen. The resulting -4 in. + 1/2 in. material is sent for tertiary crushing by a Cedarapids 40 in. x 30 in. hammer mill. The -1/2 in. fines are added to the hammer mill crushed product and passed through a 6 ft. x 14 ft. Simplicity double-deck screen to generate the desired HL product, screenings and an oversize that is returned to the hammer mill.

Fine material is screened out before entering the crushers to lighten their load.

Fiat-Allis 545, 645, and 745 loaders (2 yd., 3 yd., 5 yd., respectively) are used to stockpile material and load trucks.

## PRODUCTS

3/4 in. Crusher Run
5/8 in. Crusher Run
Granular "B"
HL 3 (-1/2 in. + 1/4 in.)
HL 4 and 5 (-5/8 in. + 1/4 in.)
HL 6 and 8 (-1 in. + 1/4 in.)

## REFERENCES

Swenson, 1957
Hewitt, 1960, p. 69-71
Swenson and Gillot, 1960
Hewitt, 1964a, p. 37
Liberty, 1971c, p. 9
Gorman and Code, 1972
Hewitt and Vos, 1972, p. 35-36
Smith, 1974
Dolar-Mantuani, 1975
Pagano and Cady, 1982
Dolar-Mantuani, 1983

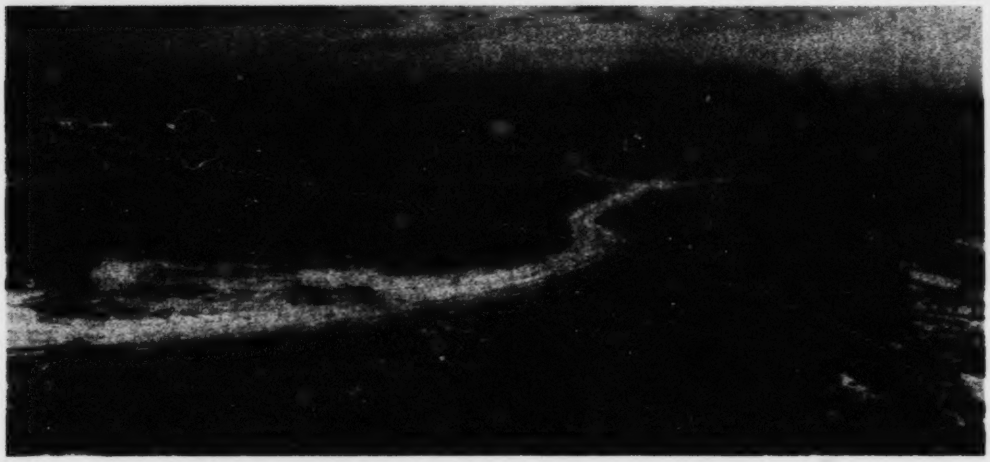


**Photo NP-32-1. VIEW OF ASPHALT BATCH PLANT (BACKGROUND) AT THE PITTSBURGH QUARRY (LOOKING NORTHEAST).**

Sabina, 1983, p. 34
Rogers, 1985

### MAPS

Wynne-Edwards, 1962, GSC Map 27-1962
Hewitt, 1964d, ODM Map 2054
Liberty, 1971b, GSC Map 18-1970
Carson, 1982c, OGS Map P.2496

## NP-33 MILL POINT QUARRY

### LOCATION AND OWNERSHIP

This quarry, located 2 km west of Marysville, Wolfe Island, in Lot 11, Registered Plan No. 73, Wolfe Island Township, Frontenac County, is operated intermittently on demand (Figure NP-33-1). The quarry is not within an area designated under the Pits and Quarries Control Act.

### GEOLOGY

The 8 m deep quarry exposes thin-bedded limestones of the upper member of the Gull River Formation. There are two uneven lifts reflecting a long history of extraction. Glacial overburden around the quarry is generally less than 0.5 m in thickness.

### Geological Section

| | | *Thickness* |
|---|---|---|
| *UNIT 1* | *Gull River Formation, upper member* | *8.0m* |
| | **Limestone: medium grey-brown to medium grey, weathers light to medium brown; microcrystalline to very fine crystalline; thin bedded (5-10 cm) with thin shale partings; very fossiliferous, especially the coral Terradium; some beds contain small intraclasts of light grey, microcrystalline limestone.** | |
| *Total thickness* | | *8.0m* |

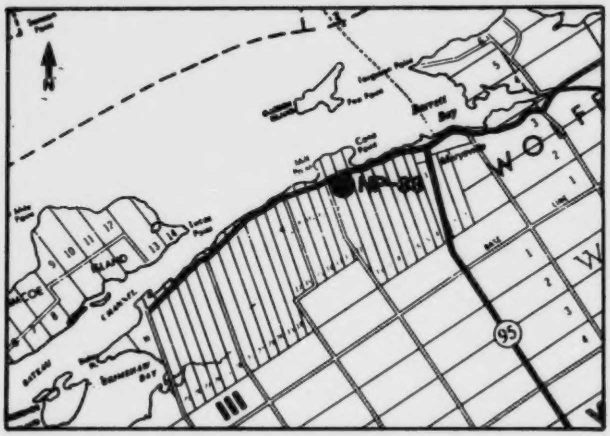


**Figure NP-33-1. LOCATION MAP FOR MILL POINT QUARRY.**

### REFERENCES

None

### MAPS

Liberty, 1971e, GSC Map 20-1970
Carson, 1982c, OGS Map P.2496

## NP-34 GRIFFIN BROTHERS (GANANOQUE) LTD. — BATTERSEA QUARRY

### LOCATION AND OWNERSHIP

This quarry, located 3 km southwest of Battersea on Frontenac County Road 10, in Lot 5, Concession 8, Storrington Township, Frontenac County is owned and operated by Griffin Brothers (Gananoque) Ltd. (Figure

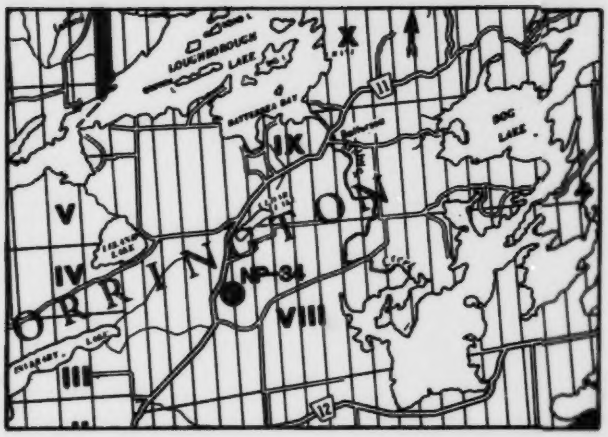


Figure NP-34-1. LOCATION MAP FOR BATTERSEA QUARRY.

NP–34–1). The quarry property covers an area of 3.2 ha.

### GEOLOGY

The 5.5 m deep quarry exposes dolostones and limestones of the lower member of the Gull River Formation. East–west trending joints in this quarry are commonly lined with calcite veins up to 0.5 cm wide. Glacial overburden around the quarry varies from 1 to 2 m in thickness.

#### Geological Section

*Thickness*

*UNIT 2 Gull River Formation, lower member* *3.5m*

**Limestone: medium to dark grey, weathers light brown on joint planes otherwise weathers medium grey; microcrystalline to very fine crystalline; thin bedded (5–10 cm) with sharp and planar contacts, rarely stylolitic; rare patches of small calcite crystals, "birdseye" texture, present; lower contact of unit sharp and planar.**

*UNIT 1 Gull River Formation, lower member* *2.0m*

**Dolostone, sandy in some beds: light green to light green-grey, weathers light green; very fine to fine crystalline; thin bedded (5–10 cm), with sharp and planar contacts; beds commonly exhibit fractures which trend 30–40 degrees from horizontal; coarse-grained, well-rounded quartz sand grains are present.**

*Total thickness* *5.5m*

### QUARRY OPERATIONS

A drill pattern of 2.7 m x 2.7 m is used with 7.6 cm diameter holes. AN/FO is used as the explosive charge and initiated with electric caps.

### PROCESSING

A portable crushing system, consisting of a primary 22 in. x 48 in. Cedarapids jaw crusher, a secondary Cedarapids 896 Commander crusher and a screening plant is set up as required.

### PRODUCTS

Rubble Rock
Granular "B" and "C"
1/2 in. chips
Screenings

### REFERENCES

Hewitt and Vos, 1972, p. 26

### MAPS

Liberty, 1971b, GSC Map 18–1970
Carson, 1982c, OGS Map P.2496

## NP–35 GRIFFIN BROTHERS (GANANOQUE) LTD. — JOYCEVILLE QUARRY

### LOCATION AND ACCESS

Griffin Brothers (Gananoque) Ltd. owns and operates this quarry in Lots 17 and 18, Concession 5, Pittsburgh Township, Frontenac County, on the southwestern outskirts of the village of Joyceville (Figure NP–35–1). The quarry licence covers an area of 63.4 ha.

### GEOLOGY

The 13.1 m deep quarry has been in operation since 1950 and exposes interbedded limestones, dolostones, shales, and sandstones of the lower member, Gull River Formation (Figure NP–35–2). Most of the quarry consists of a single lift, of approximately 5 m depth, which

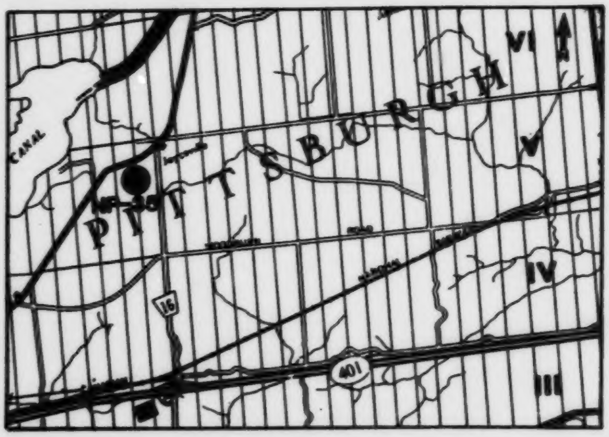


Figure NP-35-1. LOCATION MAP FOR JOYCEVILLE QUARRY.

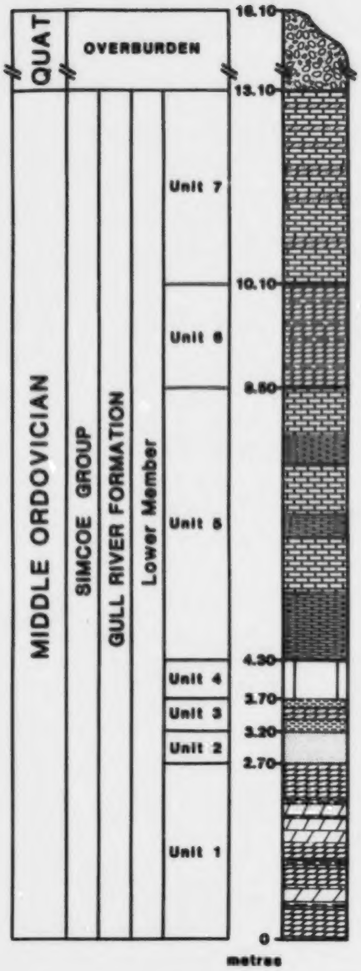


**Figure NP-35-2. STRATIGRAPHIC COLUMN FOR JOYCEVILLE QUARRY.**

reveals an irregular bedrock surface. A second, lower lift has been excavated in two places, the deeper of which exposes an additional 8.5 m of strata. The thickness of the glacial overburden varies from 1 to 3 m around this quarry site.

## Geological Section

*Thickness*

*UNIT 7 Gull River Formation, lower member 3.0m*

**Limestone, interbedded with silty dolostone: dark grey, with light brown dolostones, weathers medium grey, with medium brown dolostones; microcrystalline to very fine crystalline, with fine-crystalline dolostones; medium bedded (20-30 cm); lower contact of unit sharp and planar.**

*UNIT 6 Gull River Formation, lower member 1.6m*

**Dolostone, interbedded with shale: medium brown, weathers light brown; very fine grained; very thin bedded (1-3 cm); lower contact of unit sharp and planar.**

*UNIT 5 Gull River Formation, lower member 4.2m*

**Limestone: light to medium grey, weathers medium grey; microcrystalline to very fine crystalline; thin to medium bedded (5-15 cm); most beds bioturbated; lower contact of unit sharp and planar.**

*UNIT 4 Gull River Formation, lower member 0.6m*

**Limestone: light grey, weathers light brown to light green; fine to medium crystalline; single bed; rare calcite-filled vugs; lower contact of unit sharp and planar.**

*UNIT 3 Gull River Formation, lower member 0.5m*

**Shale, interbedded with silty dolostone: light green, weathers same; very fine grained texture in most beds; very thin bedded (1-3 cm); lower contact of unit sharp and planar.**

*UNIT 2 Gull River Formation, lower member 0.5m*

**Sandstone: medium green, weathers light green to light brown; fine-grained quartz; single bed; lower contact of unit sharp and planar.**

*UNIT 1 Gull River Formation, lower member 2.7m*

**Dolostone, interbedded with shale: medium to dark green, weathers light green; very fine crystalline; thin to medium bedded (5-20 cm) with shale beds 2-5 cm thick; small scattered crystals of pyrite present.**

*Total thickness 13.1m*

## CHEMICAL ANALYSIS*

| | Components in Percent | |
|---|---|---|
| **Above Floor (m)** | **Units 4,5** | **Units 1 to 3** |
| $SiO_2$ | 2.07 | 21.50 |
| $Al_2O_3$ | 0.66 | 4.88 |
| $Fe_2O_3$ | 0.59 | 1.64 |
| MgO | 2.24 | 8.67 |
| CaO | 51.5 | 28.8 |
| $P_2O_5$ | 0.02 | 0.06 |
| $SO_3$ | 0.26 | 1.25 |
| L.O.I. | 42.9 | 31.7 |
| Total | 100.2 | 98.5 |

* *after Hewitt and Vos, 1972, p.26-27.*

## QUARRY OPERATION

A drill pattern of 2.75 m x 2.75 m is used with 7.6 cm diameter holes. Blasting is with AN/FO and electric caps.

## PROCESSING

A portable crushing system is set up on site, consisting of a primary 22 in. x 48 in. Cedarapids jaw, and a secondary Cedarapids 896 Commander crusher feeding a screening plant. Production for 1986 was approximately 60,000 tonnes, primarily of crusher run granular products.

## PRODUCTS

Rubble Rock
Granular "B" & "C"

1/2 in. chips
Screenings

### REFERENCES

Hewitt and Vos, 1972, p. 26–27
Sabina, 1983, p. 34

### MAPS

Wynne–Edwards, 1962, GSC Map 27–1962
Hewitt, 1964d, ODM Map 2054
Liberty, 1971b, GSC Map 18–1970
Carson, 1982c, OGS Map P.2496

## NP–36 HOWE ISLAND QUARRY

### LOCATION AND OWNERSHIP

This small quarry was opened in the spring of 1986 in Lot 5, North Range, Howe Island Township, Frontenac County to supply the township with aggregate for its gravel roads (Figure NP–36–1). The quarry is not designated under the Pits and Quarries Control Act.

### GEOLOGY

When visited, the quarry was partially flooded with only 3.0 m of medium–bedded, microcrystalline limestone exposed above the water level. Light green dolomitic limestone fragments were observed in the adjacent rubble pile indicating that this quarry contains strata of the lower member of the Gull River Formation. Overburden thickness varies considerably from less than 0.5 to 3.0 m.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 1 Gull River Formation, lower member* | *3.0m* |
| Limestone: light to dark grey, grey–brown at top, too fresh to show any different weathered colours; microcrystalline to very fine crystalline; medium bedded (20–25 cm) with sharp, planar to stylolitic contacts; sparsely fossiliferous; some light green, very fine–grained, dolomitic limestone fragments found in rubble pile, lower part of quarry not visible due to water in quarry. | |
| *Total thickness* | *3.0m* |

### REFERENCES

None

### MAPS

None

## NP–37 WARREN PAVING AND MATERIALS GROUP LIMITED — WESTBROOK QUARRY

### LOCATION AND OWNERSHIP

The Westbrook Quarry, operated by Dibblee Construction Ltd. of the Warren Paving and Materials Group, extends across Lots 1, 2, and 3, Concession 4 West Division, Kingston Township, Frontenac County, just north of Highway 401 on the Westbrook Road (Figure NP–37–1). Most of the quarry production is used to supply an on–site asphalt plant. The quarry licence covers an area of 151.8 ha.

### GEOLOGY

The 5.0 m deep quarry exposes thin–bedded, shaly limestones of the upper member, Gull River Formation. The limestones range from microcrystalline to fine crystalline.

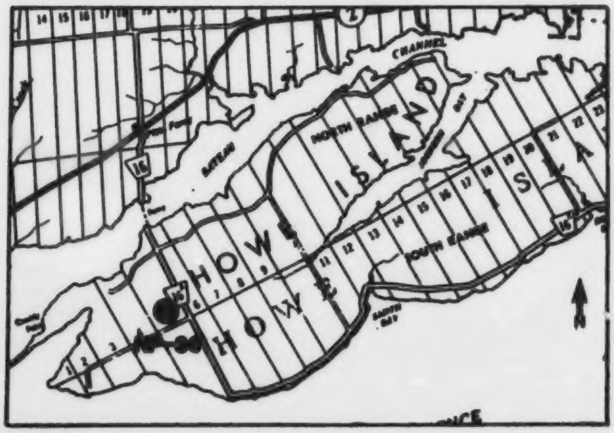


**Figure NP–36–1. LOCATION MAP FOR HOWE ISLAND QUARRY.**

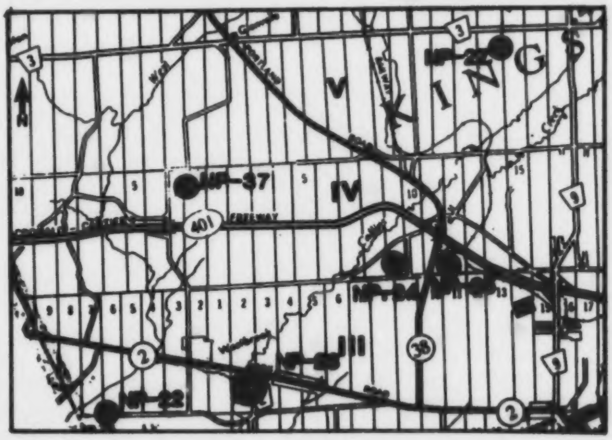


**Figure NP–37–1. LOCATION MAP FOR WESTBROOK QUARRY.**

**Photo NP-37-1. 6,500 LB. ASPHALT BATCH PLANT AT THE WESTBROOK QUARRY (LOOKING WEST).**

Glacial overburden around the quarry is generally less than 1 m thick.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 1 Gull River Formation, upper member* | *5.0m* |
| Limestone: medium to dark grey, weathers medium grey; microcrystalline to rarely fine crystalline; thin (5-10 cm) to rarely medium bedded (14-30 cm), with thin shale partings present between some beds; moderately fossiliferous; small patches of calcite crystals, "birdseye" texture, abundant. | |
| *Total thickness* | *5.0m* |

## QUARRY OPERATION

The quarry has an excavated area of about 4 ha on a single lift of 6.1 m.

Drilling and blasting is contracted; a 2.1 m x 2.7 m drill pattern is used with 6.4 cm diameter blast holes.

## PROCESSING

A portable crushing plant is transported from the Warren Paving and Materials Group Boyce Quarry (CP-18) on a demand basis.

## PRODUCTS

Granular "A"
Granular "B"

HL3

HL4

HL6

Concrete stone as required

## REFERENCES

None

## MAPS

Carson, 1981c, OGS Map P.2413

# Tweed District

## INTRODUCTION

Tweed District is situated in the Eastern Ontario Region of southern Ontario. The district is bounded on the east by Carleton Place District, on the south by Napanee District, on the west by Lindsay District, and on the north by Bancroft and Pembroke Districts. Tweed District includes the northern half of Hastings, Lennox and Addington, and Frontenac Counties (Figure TW–0–1).

Twenty–one limestone quarries are documented in the quarry inventory (Appendix IV, Volume I). Three of the limestone quarries are licensed and operate on an intermittent basis; the balance represent post–producing quarries. Ten marble quarries are also operated intermittently.

During the study, all of the intermittently active limestone and marble quarries, one historic limestone quarry,

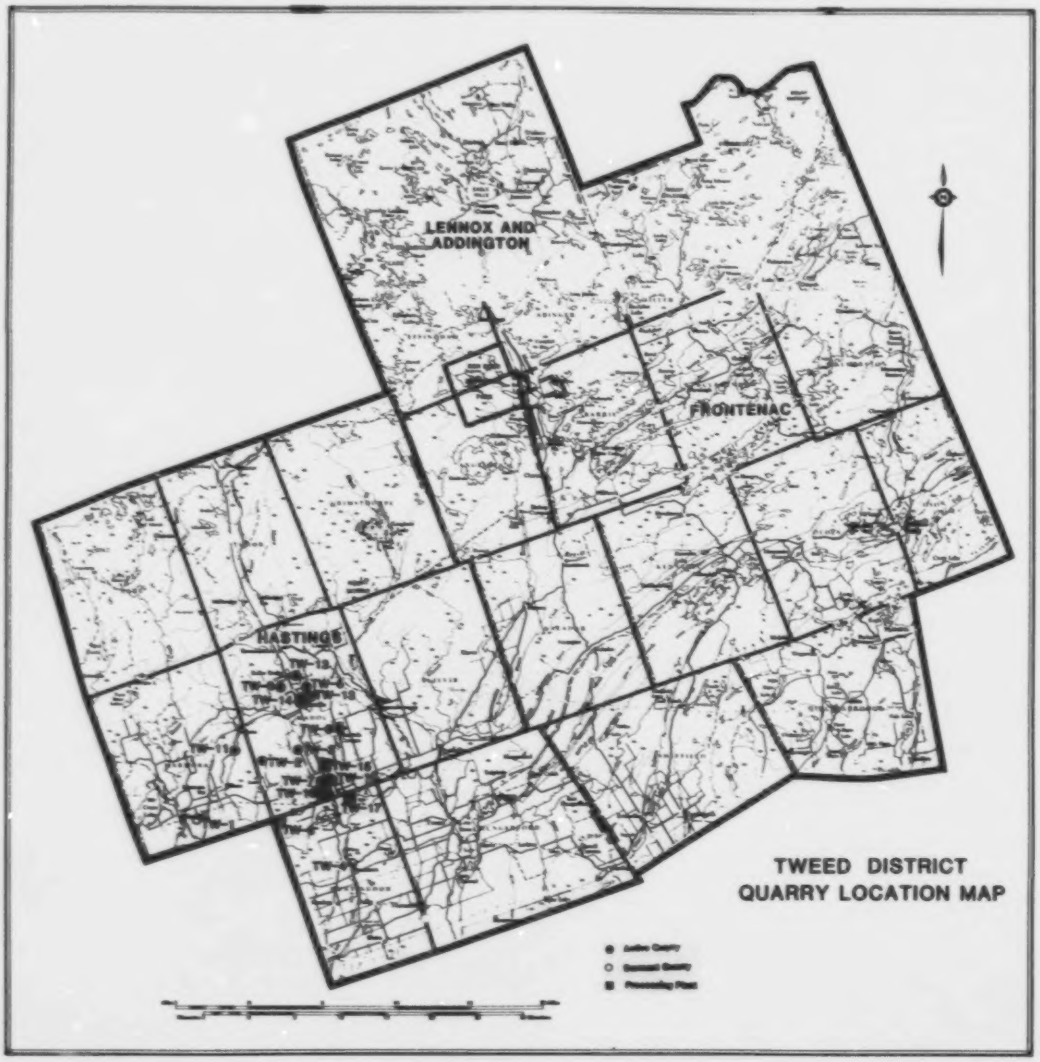

LENNOX AND ADDINGTON
FRONTENAC
HASTINGS
TW-12
TW-14
TW-11
TW-17
TWEED DISTRICT QUARRY LOCATION MAP

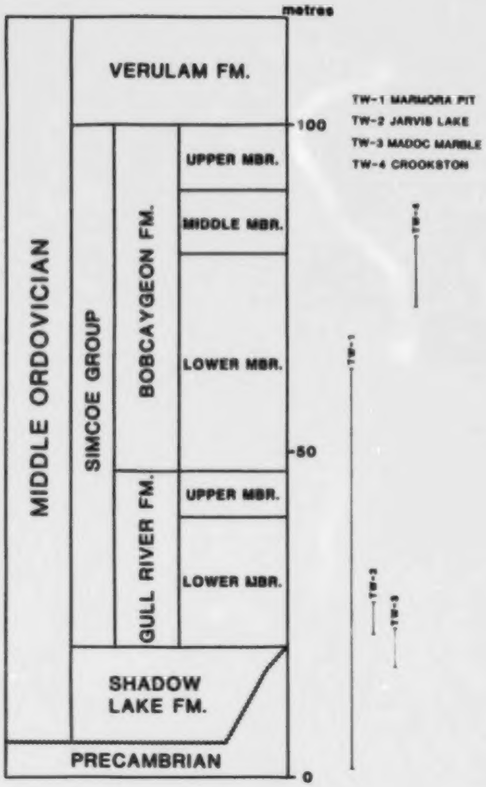
Figure TW–0–1. TWEED DISTRICT QUARRY LOCATION MAP.

two past producing marble quarries and two processing plants were visited and include the following:

| | |
|---|---|
| *TW-1* | *Marmoraton Mining Company – Marmora Pit (abandoned)* |
| *TW-2* | *Stoklosar Marble Quarries Limited – Jarvis Lake Quarry (dormant)* |
| *TW-3* | *Stoklosar Marble Quarries Limited – Madoc Marble Quarry (intermittent)* |
| *TW-4* | *H. J. McFarland Construction Co. – Crookston Quarry (dormant)* |
| *TW-5* | *Stoklosar Marble Quarries Limited – Fox Corners Pink Marble Quarry (intermittent)* |
| *TW-6* | *Stoklosar Marble Quarries Limited – Madoc Green Marble Quarry (intermittent)* |
| *TW-7* | *Stoklosar Marble Quarries Limited – Madoc Grey–Black Marble Quarry (intermittent)* |
| *TW-8* | *Stoklosar Marble Quarries Limited – Madoc Buff Marble Quarry No. 1 (intermittent)* |
| *TW-9* | *Stoklosar Marble Quarries Limited – Madoc Buff Marble Quarry No. 2 (abandoned)* |
| *TW-10* | *Stoklosar Marble Quarries Limited – Madoc Black Marble Quarry (abandoned)* |
| *TW-11* | *Stoklosar Marble Quarries Limited – Marmora Brucitic Marble Quarry (intermittent)* |
| *TW-12* | *Stoklosar Marble Quarries Limited – Keller Bridge Blue Marble Quarry (intermittent)* |
| *TW-13* | *Stoklosar Marble Quarries Limited – Eldorado Light Buff Marble Quarry (intermittent)* |
| *TW-14* | *Stoklosar Marble Quarries Limited – Eldorado Dark Buff Marble Quarry (intermittent)* |
| *TW-15* | *Stoklosar Marble Quarries Limited – Madoc Plant No. 1* |
| *TW-16* | *Stoklosar Marble Quarries Limited – Madoc Plant No. 2* |
| *TW-17* | *Canada Talc Industries Limited – Madoc Talc Mine* |

## PRECAMBRIAN GEOLOGY

Grenville marbles in the Tweed District are part of the Elzevir, Sharbot Lake and Frontenac sedimentary terranes (Bartlett et al., 1984). They are characterized by the presence of both dolomite– and calcite–dominated varieties, intercalated with occasional metavolcanic or metasedimentary beds. The marbles are fine to coarse crystalline, layered white, grey or buff, and locally they are pink and microcrystalline. A wide band of dolomitic marble between Ompah and Plevna was tested for building stone purposes (Hewitt, 1964c).



N.B.: Maximum thicknesses were assumed for this section

Marble deposits are not shown on this figure

Figure TW-0-2. STRATIGRAPHIC COLUMN SHOWING PRINCIPAL QUARRIES OF TWEED DISTRICT.

## PALEOZOIC GEOLOGY

Most of the Tweed District is underlain by Precambrian rocks of the Grenville Province. The Paleozoic rocks of the Middle Ordovician Shadow Lake, Gull River and Bobcaygeon Formations only occur in the extreme southern part of the district.

The Paleozoic–Precambrian contact approximately follows the southern boundary of the Tweed District. This contact is delineated in scattered areas by a northward–facing escarpment such as in the Tweed area. Elsewhere the contact is covered by a ramp of glacial debris.

The Paleozoic rocks in the Tweed District include the sandstones and shales of the Middle Ordovician Shadow Lake Formation (Figure TW–0–2) and the carbonate rocks of the Gull River and Bobcaygeon Formations of the overlying Simcoe Group. The Verulam and Lindsay Formations of the upper part of the Simcoe Group do not occur in Tweed District.

The Shadow Lake Formation usually consists of a basal conglomerate overlain by arkosic sandstones and shales. It varies in thickness from zero, where it is absent over Precambrian topographic highs, to up to 15 m thick where it fills lows in the Precambrian surface.

There are only small scattered exposures of the Shadow Lake Formation in the Tweed District. A complete section through the formation is exposed at the base of the Paleozoic section in the Marmora Pit (TW–1) where between 6 to 12 m of arkosic sandstones and shale overlie the irregular Precambrian surface. This formation is also exposed at the base of the Madoc Marble Quarry (TW–3).

Overlying the Shadow Lake Formation is the Gull River Formation which is exposed in southwestern Tweed District. There are several abandoned quarries which utilized the Gull River Formation in this district.

The Gull River Formation is subdivided into two members, based on the work of Williams (in prep.) and the exposure in the Marmora Pit (TW–1). This differs from the four–fold subdivision proposed by Liberty (1971c) for these strata in the Kingston area. The Gull River Formation (as defined by Williams, in prep.) varies in thickness from 30 m in the Marmora Pit to 80 m in the Kingston area.

The lower member of the Gull River Formation consists of alternating units, 0.5 to 1.5 m thick, of limestone and dolostone. The limestone is light to medium grey, thin to medium bedded and microcrystalline, and the dolostones are light brown to light green, thin to medium bedded and fine crystalline. The lower part of the member includes thin intervals of shale and quartz–rich sandstone. Several of the light green dolostone beds weather distinctively and provide excellent marker horizons. The lower member ranges in thickness from 20 m in the Marmora Pit (TW–1) to about 60 m in the Kingston area. Stone from these strata in the Jarvis Lake (TW–2) and Madoc Marble (TW–3) quarries is used for terrazzo chips.

The upper member of the Gull River Formation consists of thin–bedded, microcrystalline to fine–crystalline limestones which are interbedded with thin, dark grey, usually calcareous, shale partings. The member thickens from 7 m in the Marmora Pit (TW–1), the only significant exposure in Tweed District, to over 16 m near Napanee.

Overlying the Gull River Formation is the Bobcaygeon Formation which outcrops sporadically in the Tweed District.

The Bobcaygeon Formation is subdivided into three members, based primarily on their shale content (Williams, in prep.). The lower and upper members generally have minor amounts of interbedded shale whereas the middle member has more signficant amounts. The limestones of the lower member consist of thick to massive beds of microcrystalline limestone and medium to coarse–grained calcarenites. The middle and upper members are thin– to medium–bedded, fine– to medium–crystalline limestone and medium–grained calcarenitic limestone. The formation maintains a uniform thickness of 50 to 60 m across the region.

The 40 m thick lower member of the Bobcaygeon Formation is characterized by thick to massive–bedded (0.5 to 1.5 m thick) limestone, often with black chert nodules in many beds. Both the Crookston Quarry (TW–4) and the upper part of the Marmora Pit (TW–1) expose this member.

The middle and upper members of the Bobcaygeon Formation are both about 10 m thick throughout Tweed District. Only a thin interval of the lowermost section of the middle member is exposed in the Crookston Quarry (TW–4). The upper member is not exposed in any quarries in this region.

## LIMESTONE INDUSTRIES

The limestone and marble industries in the Tweed District produce principally marble chips for terazzo flooring, and aggregate. Marble chips are produced by Stoklosar Marble Quarries Limited at two plants and by Canada Talc Limited as a by–product of talc mining and processing. Although exact production figures are not available it is estimated that several thousand tonnes of marble chips are produced annually.

Construction aggregates are produced intermittently by Armbro Materials and Construction Ltd. from the waste limestone produced during the operation of the Marmoraton iron mine (TW–1) which ceased production in the late 1970s. Production figures are not available for this operation.

## TW–1 MARMORATON MINING COMPANY — MARMORA PIT

### LOCATION AND OWNERSHIP

This open pit mine, southeast of the Village of Marmora, on Lots 4–5, Concessions 5–6, Marmora Township, Hastings County (Figure TW–1–1), was once a major producer of iron ore from a magnetite–rich skarn in the Precambrian. A brief history of the mine is presented by Bartlett and Moore (1985, p. 188–189). The overlying Paleozoic rock was stripped off, revealing a continuous 55 m section of Middle Ordovician strata. The removal of over 20 million tonnes of limestone resulted in an open pit 800 m long and 400 m wide. It was eventually deepened to 220 m using a circular ramp system. The waste piles of limestone have recently been worked as a source for aggregate by Armbro Materials and Construc-

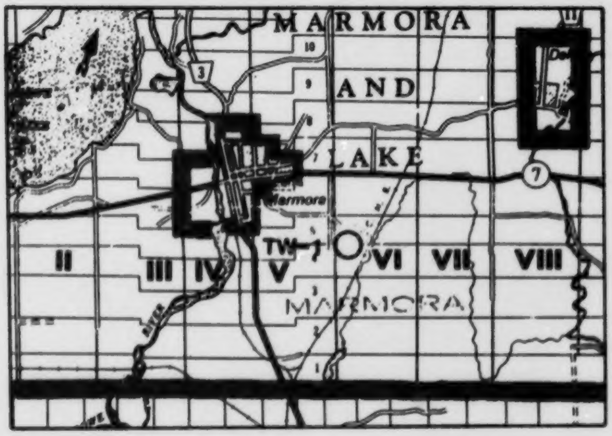

MARMORA
AND
LAKE
Marmora
TW-1
II
III
IV
V
VI
VII
VIII
MARMORA
7

Figure TW-1-1. LOCATION MAP FOR MARMORA PIT.

tion Ltd. A large quantity of limestone waste remains on the property. At the time of the field work in 1986, the lowermost part of the pit was beginning to fill with water.

## GEOLOGY

The Paleozoic strata in this pit unconformably overlie a magnetite-rich skarn of Precambrian age. The entire Shadow Lake and Gull River Formations, and part of the lower member of the Bobcaygeon Formation are exposed in the walls of the open pit (Figure TW-1-2). These excellent exposures provide a reference section for the Middle Ordovician strata in central Ontario (Williams and Thompson, 1986). A brief summary of the Paleozoic geology is presented here.

The Shadow Lake Formation can vary in thickness from 6 to 12 m due to the irregular Precambrian surface. The trace of the unconformity itself is sharp and is usually overlain by a basal conglomerate. The formation, as exposed in the pit, consists of a basal conglomerate overlain by interbedded red and green, fine- to medium-grained, dolomitic, feldspathic sandstones and siltstones. Generally, grain size decreases upwards in the formation. The contact with the overlying Gull River Formation, which is considered to be conformable, is placed at the base of the lowest carbonate bed, usually a fine-crystalline silty dolostone.

The Gull River Formation is subdivided into two members (Figure TW-1-2). The lower member consists of 19.8 m of interbedded dolostone and limestone, usually alternating in units about 1 m thick. The limestones range from microcrystalline to fine crystalline, and may include some mud and silt in the lower part of the formation. The dolostones are generally fine crystalline and may contain varying amounts of mud, silt, or sand, and may be considerably calcitic in composition. Bedding is generally thin to medium, with the dolostone beds usually thicker than the limestone beds. The contact with

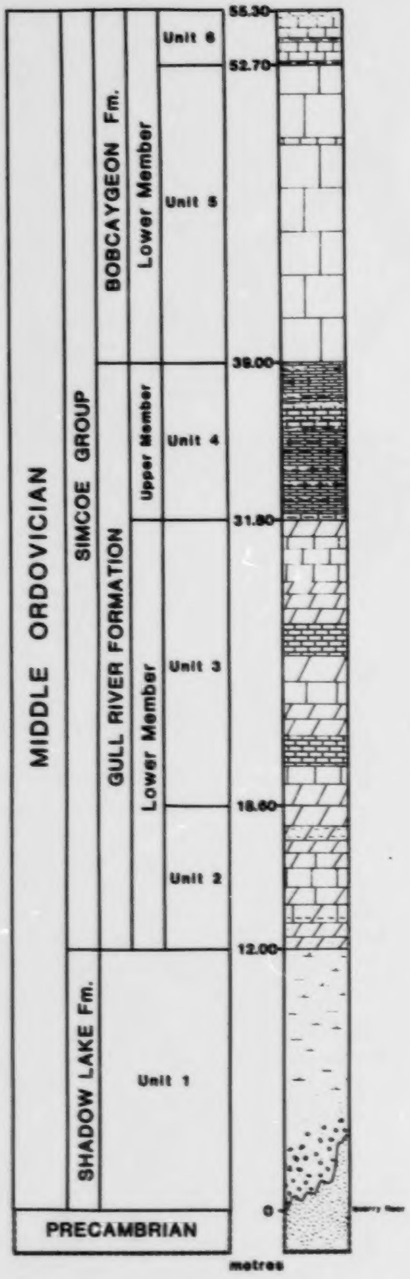

MIDDLE ORDOVICIAN
SIMCOE GROUP
BOBCAYGEON Fm.
Lower Member
Unit 6
Unit 5
GULL RIVER FORMATION
Upper Member
Unit 4
Lower Member
Unit 3
Unit 2
SHADOW LAKE Fm.
Unit 1
PRECAMBRIAN
55.30
52.70
39.00
31.80
18.60
12.00
0
metres
quarry floor

Figure TW-1-2. STRATIGRAPHIC COLUMN FOR MARMORA PIT.

the overlying upper member is placed at the top of the uppermost dolostone bed, coincident with the base of a considerably more thin-bedded shaly limestone.

The upper member of the Gull River Formation consists of 7.2 m of thin– to rarely medium-bedded limestone, with abundant shale partings. The limestones are generally microcrystalline, although fine– and medium–crystalline beds occur rarely. The contact with the overlying Bobcaygeon Formation is placed at the base of the lowest massive bed of microcrystalline to very fine–crystalline limestone. The contrast between the thin–bedded, shaly limestone of the upper member, Gull River Formation and the massive beds of the lower member, Bobcaygeon Formation clearly identifies this contact.

In the Marmora Pit, 16.3 m of the lower member of the Bobcaygeon Formation are exposed. The lower member consists of massive beds of microcrystalline limestone, with some thinner interbeds of microcrystalline to fine–crystalline limestone which coarsen upwards to include fine– to coarse-grained calcarenites. Thin shale partings occur in the uppermost portion of the section. Black chert nodules occur in a 2 m thick interval, 10 m above the base of the formation. The limestones are generally fossiliferous with brachiopods, corals, and stromatoporoids occurring in large numbers. The stratigraphic nomenclature used here follows the revisions in Middle Ordovician stratigraphy proposed by Williams (in prep.).

### REFERENCES

Winder, 1955a, p.10
Hewitt, 1960, p.45–47
Mirynech and Liberty, 1964, p. 32–33
Gross, 1967, p.80–82
Sabina, 1970, p. 136–137
Winder and Sanford, 1972, p.52–53
Winder et al., 1975, p. 140–141
Carson, 1981d, p.52–56, and Sect. C–1
Bartlett and Moore, 1985, p.188–189
Verschuren et al., 1986, p. 296–298
Williams and Thompson, 1986

### MAPS

Winder, 1955b, GSC Map 54–17
Carson, 1980a, OGS Map P.2374

## TW–2 STOKLOSAR MARBLE QUARRIES LIMITED — JARVIS LAKE QUARRY

### LOCATION AND OWNERSHIP

Stoklosar Marble Quarries Limited owns this quarry in Lot 11, Concession 1, Madoc Township, Hastings County (Figure TW–2–1). This quarry was operated intermittently for the production of terrazzo chips and ornamental stone, but has been inactive in recent years.

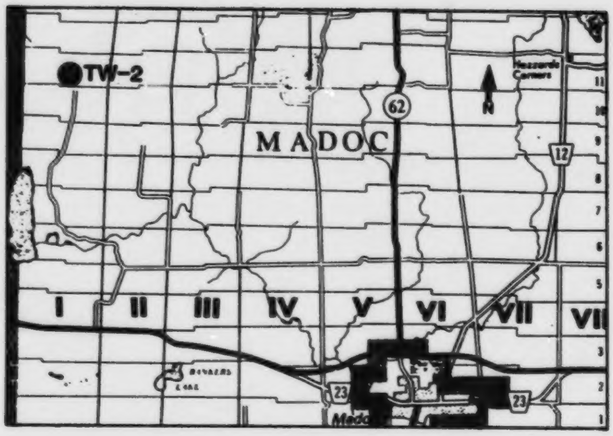


Figure TW-2-1. LOCATION MAP FOR JARVIS LAKE QUARRY.

### GEOLOGY

The quarry face exposes 4.5 m of the lower member of the Gull River Formation. A reddish–brown, sandy limestone occurs in this quarry, in addition to the more typical light grey, microcrystalline limestone. Small quartz pebbles occur in some of the sandy limestone beds. Overburden thickness is generally less than 0.5 m around the quarry.

#### Geological Section

| | Thickness |
|---|---|
| *UNIT 1 Gull River Formation, lower member* | *4.5m* |
| Limestone, with some sandy limestone: light reddish–brown to light grey, weathers light to medium reddish–brown; microcrystalline, with fine– to coarse–grained quartz grains; thin to medium bedded (5–15 cm), with sharp and planar, or stylolitic contacts, thin–laminated beds common; burrows rare to common; some iron oxide stains on quarry face. | |
| *Total thickness* | *4.5m* |

### REFERENCES

Hewitt, 1964b, p.33
Hewitt, 1964c, p. 14
Carson, 1981d, Sect. C–3
Verschuren et al., 1986, p.290–292

### MAPS

Hewitt, 1968, ODM Map 2154
Carson, 1980a, OGS Map P.2374

## TW-3 STOKLOSAR MARBLE QUARRIES LIMITED — MADOC MARBLE QUARRY

### LOCATION AND OWNERSHIP

Stoklosar Marble Quarries Limited intermittently produces terrazzo chips from the old Madoc Marble Quarry in Lot 10, Concession 4, Madoc Township, Hastings County (Figure TW-3-1). A second smaller quarry is located immediately to the northwest, also in Lot 10, Concession 4.

### GEOLOGY

The northern quarry, opening into a hillside, exposes arkoses (feldspar-rich sandstones) of the Shadow Lake Formation which are overlain by limestones of the lower member, Gull River Formation (Figure TW-3- 2). The lower 2.5 m of the quarry consists of reddish brown, thick-bedded arkosic sandstones of the Shadow Lake Formation. The overlying 3.0 m consists of light grey to light red, thin-bedded limestones of the lower member of the Gull River Formation, which are the primary source for terrazzo chips. Glacial overburden thickness (approximately 2 m) apparently increases over the hill-

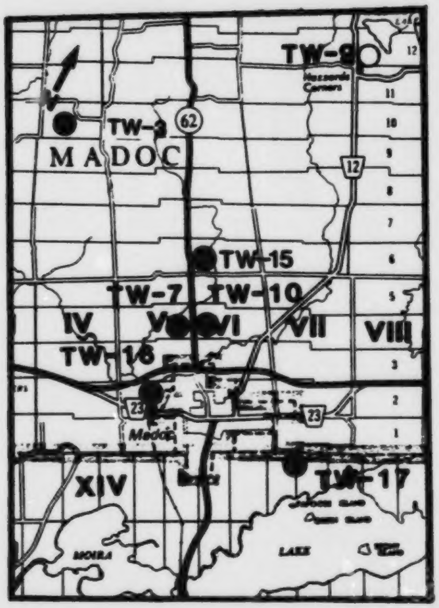

TW-9
12
11
10
9
8
7
6
5
4
3
2
1
TW-3
62
MADOC
12
TW-15
TW-7
TW-10
IV
V
VI
VII
VIII
TW-16
23
23
Madoc
XIV
TW-17
MOIRA
LAKE

Figure TW-3-1. LOCATION MAP FOR MADOC MARBLE QUARRY.

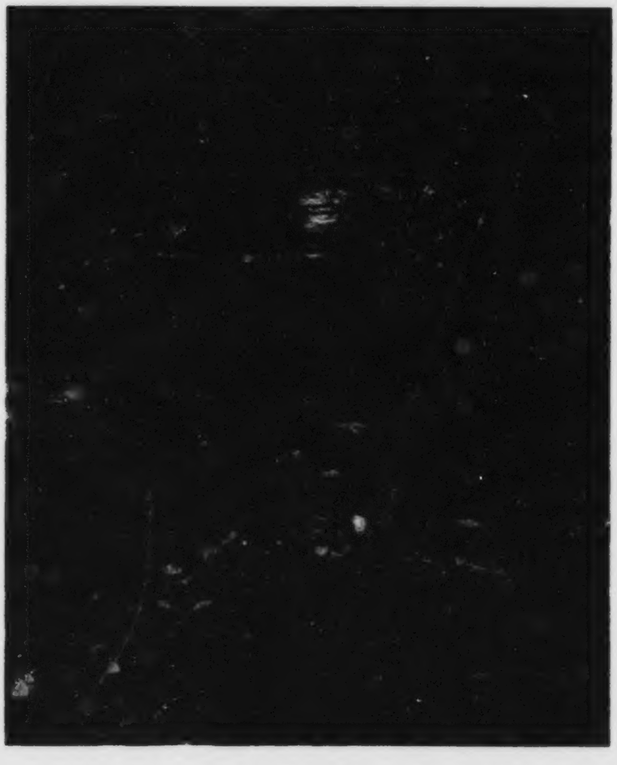


Photo TW-3-1. FACE AT MADOC MARBLE QUARRY (NORTH QUARRY).

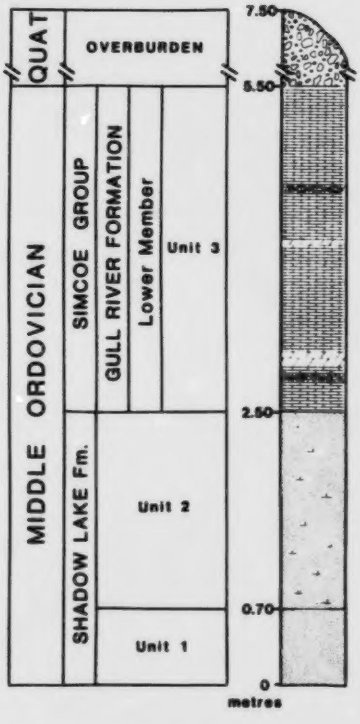

QUAT
OVERBURDEN
MIDDLE ORDOVICIAN
SIMCOE GROUP
GULL RIVER FORMATION
Lower Member
Unit 3
SHADOW LAKE Fm.
Unit 2
Unit 1
7.50
5.50
2.50
0.70
0
metres

Figure TW-3-2. STRATIGRAPHIC COLUMN FOR MADOC MARBLE QUARRY.

top. The southern quarry exposes a similar section. The thin bedding and irregular joint patterns limited these rocks to products such as terrazzo chips and architectural products.

### Geological Section

*Thickness*

*UNIT 3 Gull River Formation, lower member* *3.0m*

Limestone, interbedded with silty limestone and silty dolostone: light grey, light green to light red, weathers light red with light grey mottles; microcrystalline, interbedded with very fine-crystalline dolostones; thin bedded (4-5 cm) with sharp planar contacts producing a very evenly bedded appearance; some burrows present in silty limestone beds; silty beds are often laminated; lower contact of unit sharp and planar.

*UNIT 2 Shadow Lake Formation* *1.8m*

Calcareous arkose: mottled light red and light green, weathers mottled very light red and green; generally fine grained with pebbles and cobbles commonly present; thick (40-50 cm) bedded with sharp and planar contacts; lower contact of unit sharp and planar.

*UNIT 1 Shadow Lake Formation* *0.7m*

Arkose: dark reddish-brown, weathers dark red; fine to medium grained with pebbles and cobbles common, some up to 50 cm in diameter; single bed; contact with underlying Precambrian probably not far below floor of quarry as an outcrop of Precambrian rock occurs between the quarry and the gravel road, this also suggests that this contact is very irregular.

*Total thickness* *5.5m*

## QUARRY OPERATION

The two quarries are operated on an intermittent basis by Stoklosar Marble Quarries Limited. Both of the quarries are about the same size being approximately 10 m by 10 m and having a working face of about 5 m. The stone is quarried from a single lift by drilling and blasting. The shot rock is loaded at the face into two tandem highway trucks and delivered to one of the two processing plants currently operated by Stoklosar Marble Quarries.

## PROCESSING

The Stoklosar processing plant is described in site descriptions TW-15 and TW-16.

## PRODUCTS

Terrazzo Chips

## REFERENCES

Hewitt, 1964a, p.15
Carson, 1981d, Sect. C-2

## MAPS

Carson, 1980a, OGS Map P.2374

# TW-4 H.J. McFARLAND CONSTRUCTION CO. — CROOKSTON QUARRY

## LOCATION AND OWNERSHIP

This quarry is located on the northern outskirts of the village of Crookston, in Lot 10, Concession 9, Huntingdon Township, Hastings County (Figure TW-4-1). Once a source for building stone (Parks, 1912; Goudge, 1938), this quarry is now licensed to H. J. McFarland Construction Company who, to date, have not yet extracted any significant amount of rock.

## GEOLOGY

The quarry face, which extends eastward into a hillside, exposes 8.0 m of very thick-bedded limestone of the lower member, Bobcaygeon Formation (Figure TW-4-2). Immediately overlying the top of the quarry in the hillside is 2.5 m of the middle member of the Bobcaygeon Formation. The lower member is characterized by massive-bedded (greater than 1.0 m thick), microcrystalline to very fine-crystalline limestone. The uppermost 2 m in the quarry contains numerous nodules of hard, black chert. The overlying middle member exposed in the hillside consists of thin-bedded, medium-crystalline to medium-grained calcarenitic limestone. Glacial overburden thickens from 0.2 m eastward over the hill top.

### Geological Section

*Thickness*

*UNIT 2 Bobcaygeon Formation, middle member* *2.5m*

Limestone: grey-brown, weathers light brown; fine- to medium-grained calcarenite; thin (5-10 cm) bedded, sharp contacts, commonly with thin shale partings; fossiliferous; some black chert nodules in lower 0.5 m; lower contact of unit sharp.

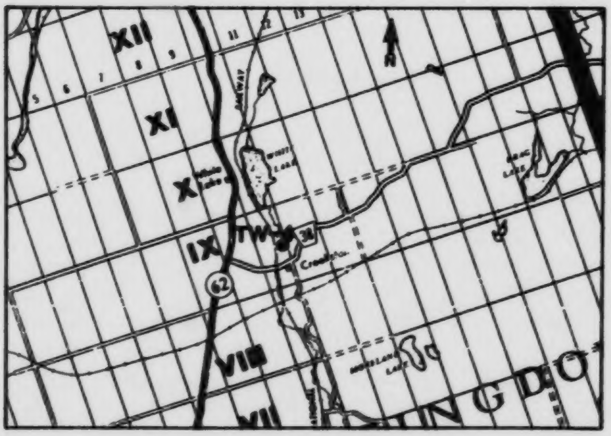


Figure TW-4-1. LOCATION MAP FOR CROOKSTON QUARRY.

*UNIT 1 Bobcaygeon Formation, lower member* *8.0m*

**Limestone: medium to dark grey, weathers light grey; microcrystalline to very fine crystalline; thick to massive bedded (0.7–1.2 m), with rare, very thin, dark grey shale partings; abundant black chert nodules common in upper 2.0 m, thin calcite veins trending east–west occur rarely; some beds very fossiliferous with very large corals, stromatoporoids, stromatolites, bryozoans, and brachiopods.**

*Total thickness* *10.5m*

## REFERENCES

Parks, 1912, p.218–220
Goudge, 1933, p. 90–91
Goudge, 1938, p.94
Liberty, 1963a, p.12
Hewitt, 1964b, p.30–31
Sabina, 1970, p. 129–130
Verschuren et al., 1985, p.63
Verschuren et al., 1986, p.270–277

## MAPS

Wilson, 1940, GSC Map 559A
Liberty, 1963b, GSC Map 24–1963
Hewitt, 1968, ODM Map 2154
Carson, 1981b, OGS Map P.2411

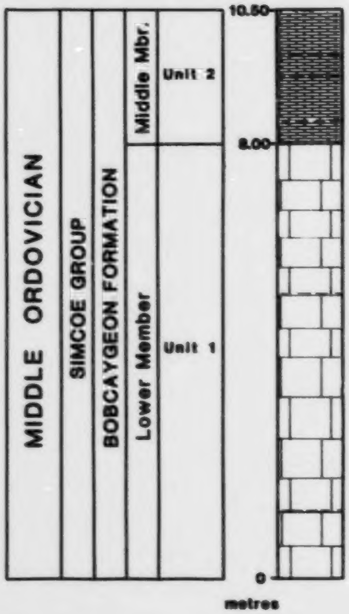


**Figure TW-4-2. STRATIGRAPHIC COLUMN FOR CROOKSTON QUARRY.**

## TW-5 STOKLOSAR MARBLE QUARRIES LIMITED – FOX CORNERS PINK MARBLE QUARRY

### LOCATION AND OWNERSHIP

Pink Grenville marble is quarried for terrazzo chips by Stoklosar Marble Quarries Limited at a site 1 km east of Fox Corners. The quarry is in the east half of Lot 20, Concession 6, Madoc Township, Hastings County (Figure TW–5–1). It is located in rolling farmland less than 100 m south of the Fox Road.

### GEOLOGY

The rock is variable in texture, but is most commonly a medium–crystalline pink calcitic marble, strongly foliated with a north–south strike, vertical dip and a lineation plunging 60° north. The texture of the rock is generally banded, comprising layers and lenses in pink, white, red and black. Fine flakes of muscovite are common on joint and foliated surfaces, and minor disseminated pyrite is occasionally present. Jointing is rather intensely developed but randomly oriented, making the quarrying of blocks unlikely. Horizontal jointing is spaced at about 1 m intervals, and vertical jointing at the same spacing is evident in two directions at right angles, trending northeast and northwest.

Outcrops are sparse in the vicinity of the quarry and the overburden averages 1 to 2 m in thickness.

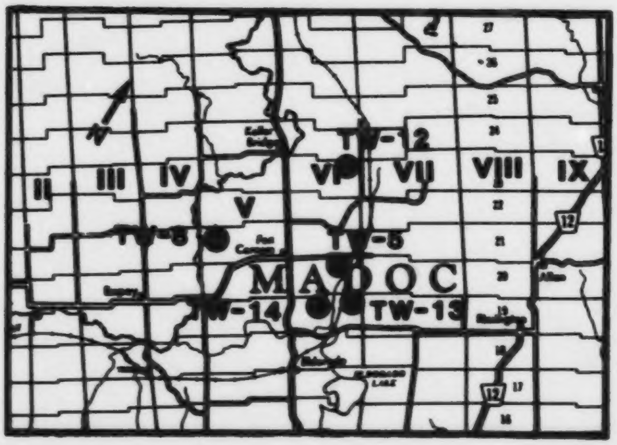


**Figure TW-5-1. LOCATION MAP FOR FOX CORNERS PINK MARBLE QUARRY.**

### PHYSICAL PROPERTIES*

| | | |
|---|---|---|
| Compressive strength, | MPa | |
| | Maximum | 102 |
| | Minimum | 79 |
| | Average | 88 |
| Absorption, percent | | 0.05 |
| Bulk Specific Gravity | | 2.71 |
| Kg per cubic metre | | 2709 |
| Abrasive hardness | | 23.1 |

### CHEMICAL COMPOSITION*

| | |
|---|---|
| Acid insoluble | 1.26% |
| Lime, CaO | 54.40% |
| Magnesia, MgO | 0.70% |
| Loss on ignition | 43.10% |
| Total | 99.46% |

* *After Hewitt, 1964c, p.43*

### QUARRY OPERATION

The quarry measures 40 m by 15 m, elongated in a northeasterly direction. It is operated on an intermittent basis with production being derived from a single bench exposing a 6 m face above a partially flooded quarry floor. The stone is quarried by drilling and blasting utilizing a jackhammer and controlled blasting methods. The broken rock is loaded at the face into two 12-tonne tandem highway trucks, using a rubber tired front end loader equipped with a 1.5 to 3.5 yd. bucket, as required, and delivered to the Stoklosar processing plants.

### PROCESSING

The stone is processed at either of the two plants currently operated by Stoklosar Marble Quarries Limited (sites TW-15 and TW-16).

### PRODUCTS

Terrazzo Chips

### REFERENCES

Hewitt, 1964c, p.43

## TW-6 STOKLOSAR MARBLE QUARRIES LIMITED — MADOC GREEN MARBLE QUARRY

### LOCATION AND OWNERSHIP

This terrazzo chip quarry, operated in a green and purple mottled calcitic marble by Stoklosar Marble Quarries Limited, is located 100 m north of the old Marmora–Madoc road in Lot 1, Concession 14, Huntingdon Township, Hastings County (Figure TW-6-1). Opened about 1960, the quarry is licensed and is operated intermittently.

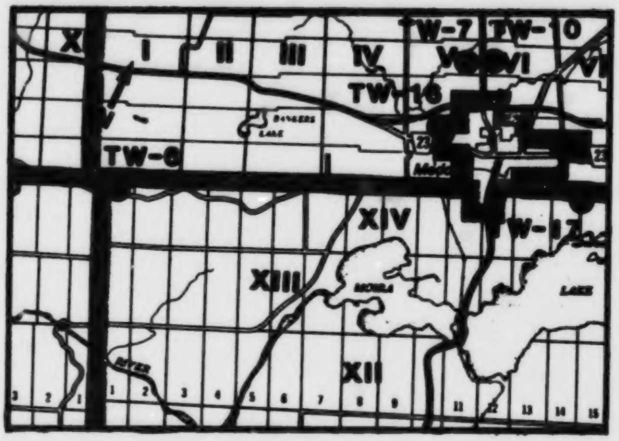


Figure TW-6-1. LOCATION MAP FOR MADOC GREEN MARBLE QUARRY.

### GEOLOGY

The marble is calcitic to weakly dolomitic, predominantly pale green in colour, but with attractive patches of mottled green and purple. According to Hewitt (1964c, p.50) "it is composed of fine-grained calcite grains with very irregular serrate intergrown boundaries which give the rock great strength. The calcite grains are intergrown with laths of chlorite and serpentine which make up at least 10% of the rock. Grain size averages 0.1 to 0.2 mm." Occasional patches of disseminated pyrite cubes are present, as are a few narrow siliceous streaks and veins. The rock is massive with a weak foliation which may reflect bedding striking east-west and dipping vertically. The deposit is of the skarn type, occurring near the contact of the Deloro granite (Verschuren et al., 1986, p. 238).

Jointing in the marble is rather irregular but not too closely spaced for the recovery of large mill blocks if desired. Vertical east-west jointing is spaced 2 m to 5 m apart and a nearly horizontal jointing is spaced at 1 m to 5 m. Fracturing due to blasting might limit the suitability of the site for dimension stone, but other deposits may exist nearby (Verschuren et al., 1986, p. 238).

### PHYSICAL PROPERTIES*

| | | |
|---|---|---|
| Compressive strength, | MPa | |
| | Maximum | 318 |
| | Minimum | 237 |
| | Average | 270 |
| Absorption, % | | 0.04 |
| Bulk specific gravity | | 2.64 |
| Kg per cubic metre | | 2,639 |
| Abrasive hardness | | 125 |

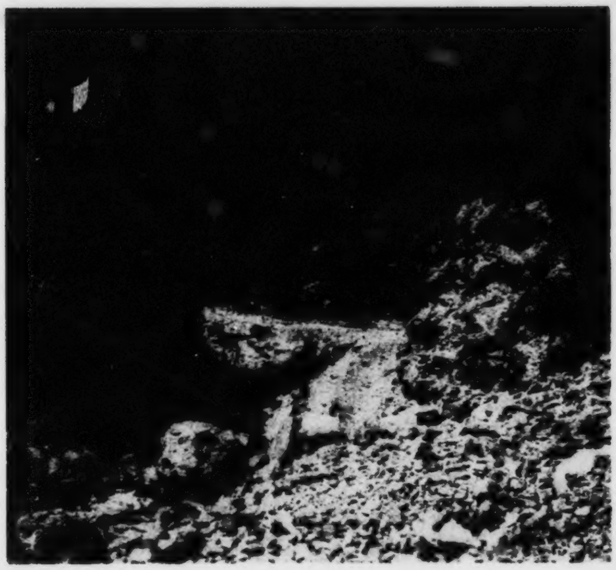


Photo TW-6-1. GREEN GRENVILLE MARBLE AT MADOC GREEN MARBLE QUARRY.

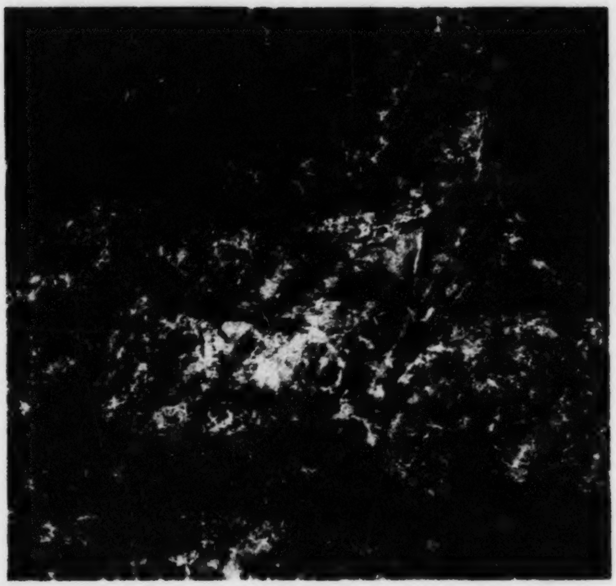


Photo TW-6-2. MOTTLED GREEN AND PURPLE GRENVILLE MARBLE AT MADOC GREEN MARBLE QUARRY.

### CHEMICAL COMPOSITION*

| | |
|---|---|
| Acid insoluble | 26.42% |
| Lime, CaO | 30.10% |
| Magnesia, MgO | 13.80% |
| Loss on ignition | 29.35% |
| Total | 99.67% |

* *Hewitt, 1964c, p. 50*

### QUARRY OPERATION

The quarry is opened into the south side of a steep ridge and is worked on two levels; an upper bench with maximum face of 16 m and a lower one of 4 m in which the floor is covered by water to a shallow depth. The workings are irregular, occupying an area of 40 m by 20 m. Drilling is done by a jackhammer and compressor. Small rounds are taken using controlled blasting methods. One of three 1.5 to 3.5 yd. front end loaders transfer the broken rock at the working face into two tandem highway trucks, each having a capacity of 12 tonnes, for delivery to the Stoklosar processing plants.

### PROCESSING

The stone is processed at either one of two plants currently operated by Stoklosar Marble Quarries Limited (sites TW-15 and TW-16).

### PRODUCTS

Terrazzo Chips

### REFERENCES

Hewitt, 1964c, p.50
Verschuren et al., 1986, p.238

## TW-7 STOKLOSAR MARBLE QUARRIES LIMITED — MADOC GREY-BLACK MARBLE QUARRY

### LOCATION AND OWNERSHIP

This quarry is located in Lot 4, Concession 5, Madoc Township, Hastings County (Figure TW-7-1) and is worked as needed by Stoklosar Marble Quarries Limited. It is opened into the north flank of a hill at a point 300 m west of Highway 62.

### GEOLOGY

The marble is grey-black on the fresh surface, weathering to medium-grey with noticeable rustiness on old fractures. Clastic quartz grains comprise about 10% (Hewitt, 1964c, p.38). Bedding is thin and strikes 030° and dips 50°E.

Jointing is moderately to intensively developed in an irregular pattern. Northwest trending vertical jointing is most common. The site is unsuitable for blocks of any

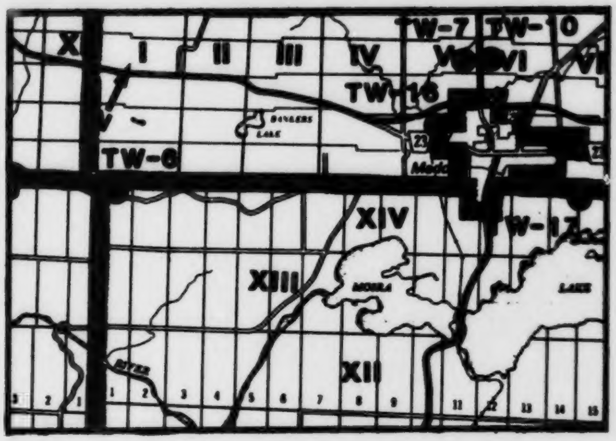


Figure TW-7-1. LOCATION MAP FOR MADOC GREY-BLACK MARBLE QUARRY.

size because of jointing but is satisfactory for terrazzo chips.

Outcrops in the vicinity of the quarry are scarce and overburden probably averages about 30 cm.

### PHYSICAL PROPERTIES*

| | | |
|---|---|---|
| Compressive strength, | MPa | |
| | Maximum | 157 |
| | Minimum | 118 |
| | Average | 135 |
| Absorption, % | | 0.05 |
| Bulk specific gravity | | 2.73 |
| Kg per cubic metre | | 27.28 |
| Abrasive hardness | | 35.3 |

### CHEMICAL COMPOSITION*

| | |
|---|---|
| Acid insoluble | 15.40% |
| Lime, CaO | 45.40% |
| Magnesia, MgO | 1.28% |
| Loss on ignition | 36.11% |
| Total | 98.19% |

* *Hewitt, 1964c, p.37-40.*

### QUARRY OPERATION

The quarry measures approximately 25 m x 10 m with limited production being derived from a single lift with a 5 m working face. At the time of the visit there was some water on the quarry floor. The stone is quarried by drilling and blasting. The blasted rock is loaded into two 12-tonne tandem highway trucks at the working face by either a 1.5 yd. or 3.5 yd. front-end loader and transported to either of the two processing plants currently operated by Stoklosar Marble Quarries Limited.

### PROCESSING

The stone is processed at either one of Stoklosar's plants (sites TW-15 or TW-16).

### PRODUCTS

Terrazzo Chips

### REFERENCES

Hewitt, 1964c, p.38
Verschuren et al., 1986, p.241

## TW-8 STOKLOSAR MARBLE QUARRIES LIMITED — MADOC BUFF MARBLE QUARRY NO. 1

### LOCATION AND OWNERSHIP

Fine-crystalline, buff coloured marble has been quarried at three sites in Lots 21 and 22, Concession 5, Madoc Township, Hastings County (Figure TW-8-1). The original workings are near the old Eldorado Talc Mine on the east side of the Moira River, while quarrying by Stoklosar Marble Quarries Limited is now periodically active in Lot 21. A third quarry, now inactive, is located 1 km to the east near Fox Corners.

### GEOLOGY

The marble is a surprisingly uniform, fine-crystalline dolomite with an attractive pale pink-brown, beige or buff colour, weathering to cream-grey brown. The stone is medium bedded with individual beds varying from 20 cm to 40 cm. Texture of the stone within individual beds is massive to weakly foliated. Bedding strikes 150° and dips 45°NE.

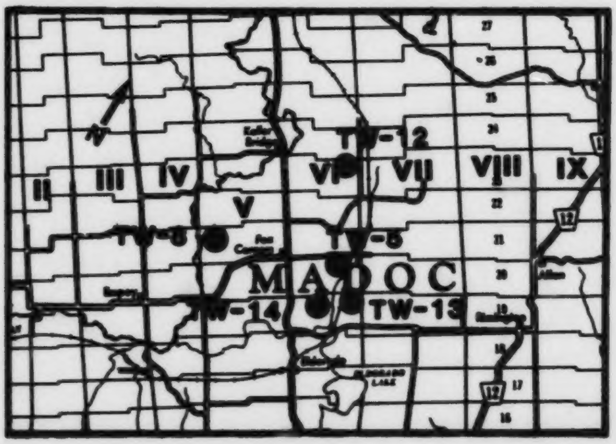


Figure TW-8-1. LOCATION MAP FOR MADOC BUFF MARBLE QUARRY NO. 1.

Hexagonal mica crystals, both white and yellow in colour, are locally common in books up to several millimetres in diameter, but form less than 1% of the rock overall. Similarly, streaks of mauve–purple coloration, perhaps caused by hematite dust, are rarely present. Thin stringers of white quartz up to 1 cm in thickness are also rarely present.

The marble is moderately to intensively jointed on a scale that would prevent the quarrying of blocks. Vertical joints in a direction of 070° are spaced at 30 cm to 1 m intervals. More closely spaced (5 cm to 30 cm) jointing strikes 110° and dips 70°S. The stone is suitable for terrazzo chips and decorative landscaping.

### QUARRY OPERATION

The principal quarry area in Lot 22 is at the north end of a bush road that provides access from the Fox Corners–Empey Road via the old talc mine. The Stoklosar quarry is located along strike of a low ridge and adjoins an older water–filled quarry which occupies an area of about 60 m by 20 m with a face oriented toward the south. The current production is derived from a single lift which has opened an area of approximately 60 m x 30 m with a 5 m working face. Drilling is by jackhammer and compressor and only small volumes of stone are blasted at a time. Two tandem highway trucks, each having a 12–tonne capacity, are loaded at the face by one of three rubber–tired loaders equipped with 1.5 to 3.5 yd. buckets as required and the stone is delivered to either one of the two Stoklosar processing plants.

### PROCESSING

The delivered stone is processed by Stoklosar at either their main plant located immediately north of Madoc or their smaller plant west of Madoc (sites TW–15 and TW–16).

### PRODUCTS

Terrazzo Chips

### REFERENCES

Hewitt, 1964c, p.39

## TW–9 STOKLOSAR MARBLE QUARRIES LIMITED — MADOC BUFF MARBLE QUARRY NO. 2

### LOCATION AND OWNERSHIP

Buff dolomitic marble was formerly quarried by Stoklosar Marble Quarries Limited in Lot 12, Concession 8, Madoc Township, Hastings County (Figure TW–9–1). There are several irregular quarry openings on the east side of County Road 12 just north of Hazzards Corners. The main quarry is 60 m by 15 m with a depth of 10 m and was worked on two levels. A smaller quarry to the south is 10 m by 6 m with a 5 m face.

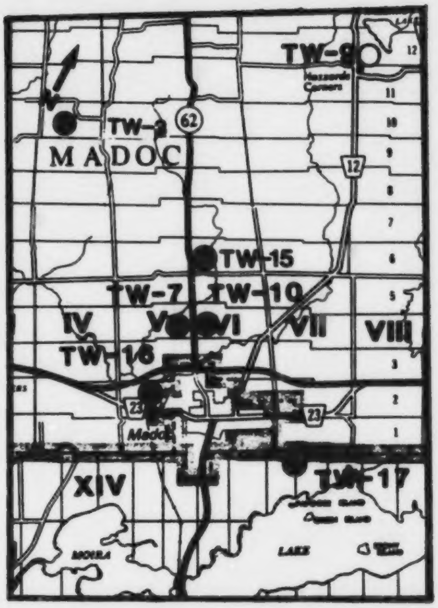


Figure TW–9–1. LOCATION MAP FOR MADOC BUFF MARBLE QUARRY NO. 2.

### GEOLOGY

The stone is uniformly microcrystalline and grey–buff in colour, weathering to mottled brown and black. The fabric is weakly laminated due to a thin wavy bedding which strikes north–south and dips 70°W. Numerous thin (1 to 2 mm) streaks of white quartz cut across the bedding and there are occasional concentrations of pyrite cubes to 5 mm in size. While bedding is obvious on the weathered surface, it is all but obscure on freshly broken rock.

Intensive jointing makes the stone suitable for chips only. Vertical jointing strikes N15°E with a spacing of 10 cm to 1 m. A northwesterly–trending joint system dips 70°SW at a spacing of 30 cm to 60 cm. Horizontal jointing is spaced at 10 cm to 30 cm.

Bedrock exposures are poor and overburden depth averages about 30 cm.

These quarries could be worked again if there was a demand for chips of this colour. Physical properties of the stone are reported to be as follows:

### PHYSICAL PROPERTIES*

| | | |
|---|---|---|
| Compressive strength | MPa | |
| | Maximum | 297 |
| | Minimum | 157 |
| | Average | 206 |
| Absorption | | 0.13% |
| Bulk specific gravity | | 2.84 |
| Kg per cubic metre | | 2,825 |
| Abrasive hardness | | 46.6 |

* *After Hewitt, 1964c, p.46.*

### REFERENCES

Hewitt, 1964c, p.46

## TW-10 STOKLOSAR MARBLE QUARRIES LIMITED — MADOC BLACK MARBLE QUARRY

### LOCATION AND OWNERSHIP

This dormant quarry located in Lot 4, Concession 6, Madoc Township, Hasting County (Figure TW-10-1) is situated on the north side of a hill on the east side of Highway 62. The quarry was previously operated by Stoklosar Marble Quarries Limited and currently occupies an area about 30 m by 10 m and has a 5 m working face.

### GEOLOGY

Initially opened in fairly uniform blue-grey to black fine-grained marble, quarrying advancing to the south has intersected thinly laminated marble in which the dark marble is interlayered with coarser recrystallized white calcite and quartz, the latter comprising 20 to 30% overall (Hewitt, 1964c, p. 39). Bedding strikes 040° and dips 55°SE. Rustiness is common on some of the weathered beds.

Jointing is moderately developed but irregular. Most common jointing is vertical, trending northwesterly with a spacing of about 50 cm. Block sizes of 100 cm by 50 cm by 50 cm may be possible.

Overburden is thin and outcrops in the vicinity of the quarry are abundant.

### PHYSICAL PROPERTIES*

| | | |
|---|---|---|
| Compressive strength, | MPa | |
| | Maximum | 197 |
| | Minimum | 89 |
| | Average | 143 |
| Absorption, % | | 0.09 |
| Bulk specific gravity | | 2.67 |
| Kg per cubic meter | | 2,669 |
| Abrasive hardness | | 45.6 |

* *Hewitt, 1964c, p.37-40.*

### REFERENCES

Hewitt, 1964c, p. 37-40

## TW-11 STOKLOSAR MARBLE QUARRIES LIMITED — MARMORA BRUCITIC MARBLE QUARRY

### LOCATION AND OWNERSHIP

Cream-coloured, brucitic marble is periodically quarried on the west bank of the Moira River south of Malone in Lot 14, Concession 10, Marmora Township, Hastings County (Figure TW-11-1). Access is provided by a cottage road leading from County Road No. 11 at a point 2 km south of Malone.

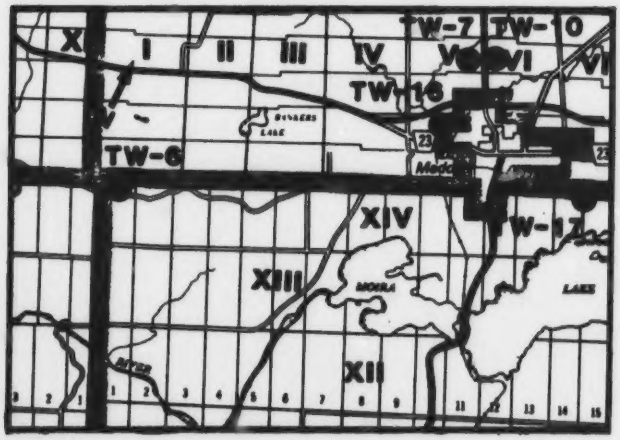


**Figure TW-10-1. LOCATION MAP FOR MADOC BLACK MARBLE QUARRY.**

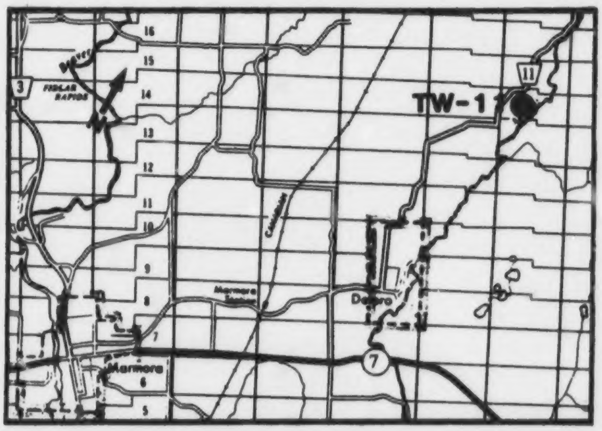


**Figure TW-11-1. LOCATION MAP FOR MARMORA BRUCITIC MARBLE QUARRY.**

Photo TW-11-1. WEATHERED MARBLE AND TALCOSE DYKE AT MARMORA BRUCITIC MARBLE QUARRY.

### GEOLOGY

The marble is calcitic and cream–grey in colour, but it varies to buff–yellow and pale green. The weathered surface is grey, mottled with brown, and it has an abrasive texture due to the more rapid weathering of the chalky white brucite. Serpentine and tremolite are accessory minerals. Crystal size is fine to medium, and the texture of the rock is generally massive except where serpentine is more abundant, when a weak foliation is evident striking 030° and dipping 70°E. A green and black dyke of talcose rock 1 m thick cuts the marble with a strike of 130° and a dip of 45°NE.

The stone is intensely fractured and jointed, restricting its use to terrazzo and decorative landscaping. There is no regular jointing pattern although one common orientation is 115° with a vertical dip and a spacing of 15 cm to 1 m. Various other joint orientations include some nearly horizontal and some with shallow easterly dips. Brown staining on weathered surfaces and fractures appear to be responsible for a substantial amount of rock being discarded as waste.

### QUARRY OPERATION

Sporadic quarrying is reported to have taken place at this site since 1938, but the most consistent activity has been since 1981 (Bartlett and Moore, 1985, p.194).

There are at least six openings exposing rock faces of 5 m to 10 m over an area of about 200 m by 100 m. All are worked in a single bench with a common floor elevation of about 1 m above the adjacent river. The stone is quarried by drilling and blasting. The product from the quarry is loaded into two 12–tonne tandem highway trucks and delivered to the designated Stoklosar processing plant.

### PROCESSING

The delivered stone is processed at either one of the two plants currently owned by Stoklosar Marble Quarries Limited (sites TW–15 and TW–16).

### PRODUCTS

Terrazzo Chips

### REFERENCES

Bartlett and Moore, 1985, p.194

## TW–12 STOKLOSAR MARBLE QUARRIES LIMITED — KELLER BRIDGE BLUE MARBLE QUARRY

### LOCATION AND OWNERSHIP

This small quarry in blue Grenville marble is periodically worked by Stoklosar Marble Quarries Limited. Located about 1.5 km due east of the hamlet of Keller Bridge, the quarry is in the east half of Lot 23, Concession 6, Madoc Township, Hastings County (Figure TW–12–1).

### GEOLOGY

The rock is a uniformly medium blue–grey, aphanitic, dolomitic marble that is nearly white on weathered surfaces. Its texture is massive and dense, but it contains minor streaks of white quartz which in places form a ribbon pattern of closely–spaced parallel veins individually ranging to 2 cm in thickness. Joint planes are moderately

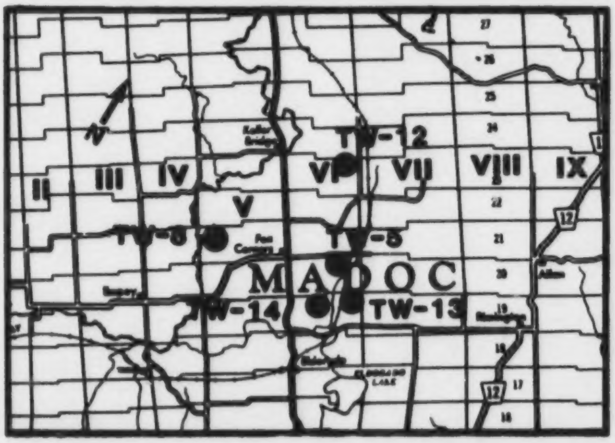


Figure TW-12-1. LOCATION MAP FOR KELLER BRIDGE BLUE MARBLE QUARRY.

frequent but irregularly oriented, so that maximum quarry blocks of about 1 cubic meter might be recovered. The most economic utilization, however, is as chips for terrazzo applications.

Bedrock exposure is poor, and overburden is moderately thick.

### QUARRY OPERATION

The quarry is being developed on the east flank of a low ridge of marble and occupies an area of approximately 12 m by 12 m exposing a 10 m working face. Limited production is derived from a single lift by drilling and blasting. The broken rock is loaded at the face and delivered to one of the Stoklosar processing plants.

### PROCESSING

The details of the Stoklosar processing plant are summarized in TW–15 and TW–16.

### PRODUCTS

Terrazzo Chips

### REFERENCES

None

## TW–13 STOKLOSAR MARBLE QUARRIES LIMITED — ELDORADO LIGHT BUFF MARBLE QUARRY

### LOCATION AND OWNERSHIP

Light buff–coloured marble chips are obtained by Stoklosar Marble Quarries Limited from a quarry in the east half of Lot 19, Concession 6, Madoc Township, Hastings County (Figure TW–13–1). The quarry is being developed on the southeast flank of a high wooded knoll located 1.5 km northeast of Eldorado.

### GEOLOGY

The marble is dolomitic, and is fine crystalline to microcrystalline. While it is dominantly pale buff, there is some variation due to a grey shadow coloration and there are occasional patches of mauve–pink hematitic coloration and red fracture alterations. Streaks of white quartz to 2 mm in thickness may locally form as much as 5 percent of the rock.

Moderate jointing is irregularly developed, the most consistent being a vertical pattern striking east–west and spaced at 25 cm to 2 m. However, other random jointing, fracturing, and foliation due to flowage would inhibit the recovery of large blocks.

### QUARRY OPERATION

The quarry is operated intermittently by Stoklosar Marble Quarries Limited. The stone is quarried by drilling and blasting and production derived from a single lift consisting of an area about 50 m by 15 m with a working face of approximately 10 m. The blasted rock is loaded at the face and transported to the Stoklosar plant for processing.

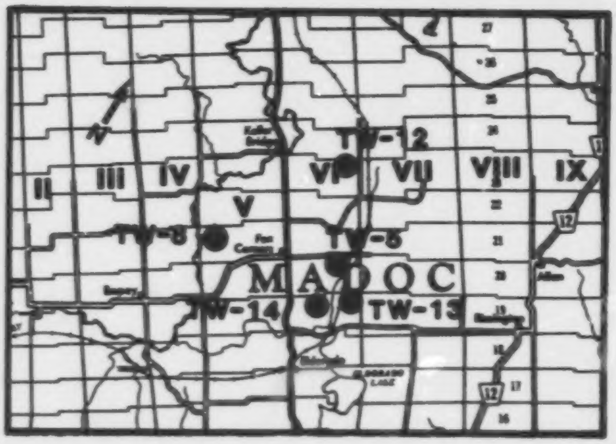


Figure TW-13-1. LOCATION MAP FOR ELDORADO LIGHT BUFF MARBLE QUARRY.

### PROCESSING

The Stoklosar processing plant is described in site descriptions TW–15 and TW–16.

### PRODUCTS

Terrazzo Chips

### REFERENCES

None

## TW–14 STOKLOSAR MARBLE QUARRIES LIMITED — ELDORADO DARK BUFF MARBLE QUARRY

### LOCATION AND OWNERSHIP

Stoklosar Marble Quarries Limited works a quarry about 1 km northeast of Eldorado in dark buff Grenville marble. The quarry is located on the west half of Lot 19, Concession 6, Madoc Township, Hastings County (Figure TW–14–1). It is opened on the crest of a high wooded ridge.

### GEOLOGY

The marble is fine crystalline to microcrystalline dolomitic, and massive to somewhat foliated. It is rather variable in colour with shades of buff–brown, and in places has streaks and patches of white, mauve and blue–grey. Lenticles of white quartz may compose up to

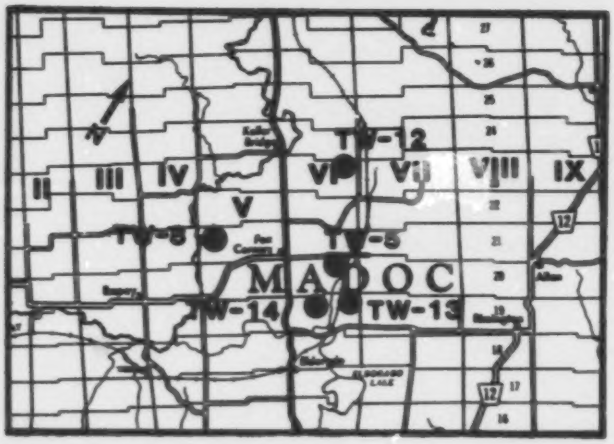


**Figure TW-14-1. LOCATION MAP FOR ELDORADO DARK BUFF MARBLE.**

5 percent of the rock in places. The rock strikes north–south and dips east at 70°. It is intensely jointed in an irregular pattern, the only consistent direction being east–west, vertical, and spaced from 2 cm to 50 cm. Fracturing, jointing and foliation would prevent the recovery of blocks; the quarry is worked exclusively for terrazzo chips.

### PHYSICAL PROPERTIES*

| | | |
|---|---|---|
| Compressive strength | MPa | |
| | Maximum | 244 |
| | Minimum | 196 |
| | Average | 220 |
| Absorption, % | | 0.10 |
| Bulk, specific gravity | | 2.85 |
| Kg per cubic metre | | 2,834 |
| Abrasive hardness | | 25.9 |

* *After Hewitt, 1964c, p.42.*

### QUARRY OPERATION

The quarry is operated on an intermittent basis by Stoklosar Marble Quarries Limited and is being developed on the crest of a marble ridge. It is irregular and occupies an area of about 50 m by 35 m exposing an 8 m working face. Blast holes are drilled with a jackhammer and small volumes of rock are blasted at a time. The broken rock is loaded at the face by a rubber–tired front end loader, equipped with 1.5 to 3.5 yd. buckets as required, into two 12–tonne tandem trucks for delivery to one of the Stoklosar processing plants.

### PROCESSING

The Stoklosar processing plant is described in site descriptions TW–15 and TW–16.

### PRODUCTS

Terrazzo chips

### REFERENCES

Hewitt, 1964c, p.42

## TW–15 STOKLOSAR MARBLE QUARRIES LIMITED — MADOC PLANT NO. 1

### LOCATION AND OWNERSHIP

Stoklosar Marble Quarries Limited currently operate two stone processing plants in the Madoc, Ontario area (Figure TW–15–1). Both plants receive quarry run material by truck from any of the previously described quarries currently owned or leased by Stoklosar in Hastings County.

The main plant is located in the southwest corner of Lot 6, Concession 6, Madoc Township approximately 1 km north of the Village of Madoc on the east side of Highway 62.

### PROCESSING

The delivered stone is off–loaded into a storage bin which feeds a 14 in. by 30 in. primary jaw crusher. The crusher discharge is conveyed to a surge bin which feeds a "picking belt" where obvious waste material and off–colour rock is removed before the stone is fed into a 10 in. x 14 in. secondary jaw crusher which discharges the

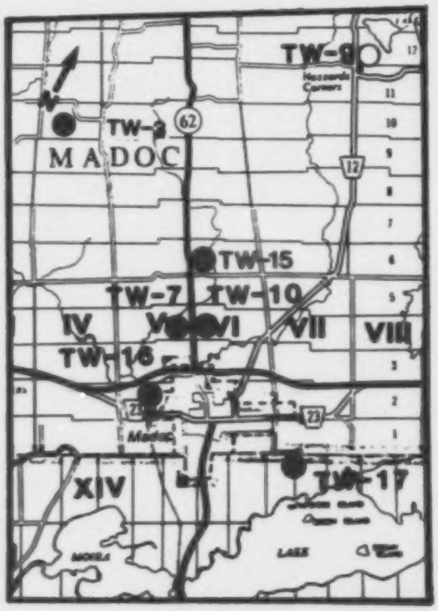


**Figure TW-15-1. LOCATION MAP FOR MADOC PLANT NO. 1.**

stone into a secondary surge bin. The stone is fed from the secondary surge bin to a hammer mill which is in closed circuit with a 3 ft. x 8 ft. triple-deck vibrating screen. Screened products are collected in six bins, all equipped with bagging facilities. Most of the production is sold in heat-sealed plastic bags of 100 lb. capacity. Minor amounts are sold in 50 lb. bags for stucco use. Bulk shipments can also be made.

### PRODUCTS

Six principal chip sizes are marketed, plus undersized dust products, as follows:

| Product Designation | Chip size (inches) |
|---|---|
| 0 | -1/8+1/16 |
| 1 | -1/4 +1/8 |
| 2 | -3/8+1/4 |
| 3 | -5/8 +3/8 |
| 5 | -7/8+5/8 |
| 7 | -1 1/4 +7/8 |
| Dust Products | -1/16 |

## TW-16 STOKLOSAR MARBLE QUARRIES LIMITED — MADOC PLANT NO. 2

### LOCATION AND OWNERSHIP

The Stoklosar Madoc No. 2 plant (Figure TW-16-1) is smaller than the main plant and is located in Lot 2, Concession 5, Madoc Township on the west side of the Village of Madoc.

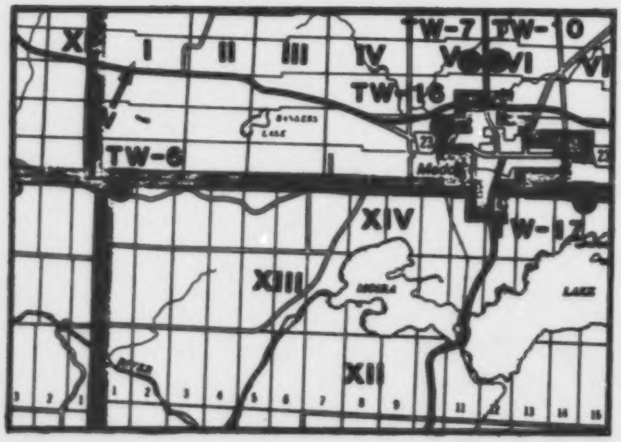


Figure TW-16-1. LOCATION MAP FOR STOKLOSAR MADOC PLANT NO. 2.

Photo TW-16-1. STOKLOSAR PROCESSING PLANT NO. 2.

### PROCESSING

The delivered stone is off-loaded into a storage bin which feeds a 12 in. x 20 in. primary jaw crusher. As at the main plant, the crusher discharge is stored in a surge bin and provides feed for the "picking belt" where the obvious waste material and off-colour rock is removed. The stone is then delivered to a hammer mill which is in closed circuit with a 3 ft. by 13 ft. triple-deck screen. The screened products are stored in 8-tonne storage bins equipped with bagging facilities. The products are bagged in 100 lb. capacity plastic bags.

### PRODUCTS

Six principal chip sizes are marketed, plus undersized dust products, as follows:

| Product Designation | Chip size (inches) |
|---|---|
| 0 | -1/8+1/16 |
| 1 | -1/4 +1/8 |
| 2 | -3/8 +1/4 |
| 3 | -5/8 +3/8 |
| 5 | -7/8 +5/8 |
| 7 | -11/4+7/8 |
| Dust Products | -1/16 |

## TW–17 CANADA TALC LIMITED — MADOC TALC MINE

### LOCATION AND OWNERSHIP

Canada Talc Limited operates a talc mine near Madoc, Ontario. The mine is located in Lots 14 and 15, Concession 14, Huntingdon Township, Hastings County (Figure TW–17–1) and has seen limited but continuous production since 1896.

### GEOLOGY

A fine–grained white dolomitic marble, with or without minor amounts of talc, tremolite, calcite, and pyrite is the host rock for foliated lenses of talc.

### QUARRY/MINE OPERATION

The mine comprises a past producing open pit and underground operation with development on eight working levels to a depth of 180 m. Canada Talc, in addition to producing a good quality talc, produces terrazzo chips from the host white, fine–grained dolomitic marble.

### PROCESSING

The marble chips are produced as a by–product of talc mining and processing at the Canada Talc plant.

### PRODUCTS

Terrazzo Chips

### REFERENCES

None

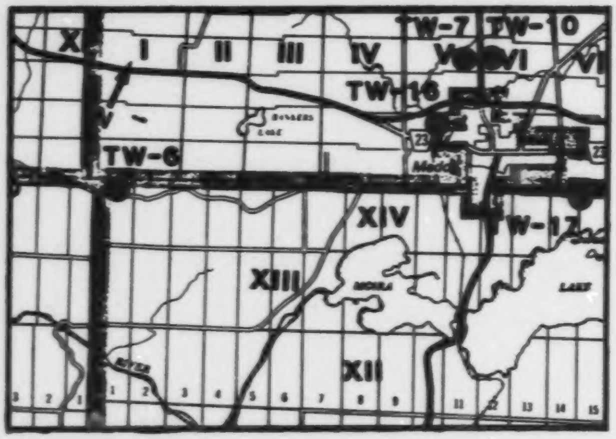


Figure TW–17–1. LOCATION MAP FOR MADOC TALC MINE.

# Pembroke District

## INTRODUCTION

The Pembroke District is situated in the Algonquin Region of southern Ontario, bounded in the north and east by the Ottawa River, on the south by the Districts of Carleton Place and Tweed and on the west by Bancroft, Algonquin Park and North Bay Districts. The district includes all of the County of Renfrew (Figure PE–0–1).

Six quarries are documented in the Pembroke District Quarry Inventory; one is active and two report intermittent production. In addition, Timminco Metals Division of Timminco Ltd. operates two marble quarries to provide stone for their magnesium plant.

The sites visited during the study include:

| | |
|---|---|
| *PE–1* | *Fourth Chute Quarry* |
| *PE–2* | *Smiths Construction Co. Ltd. – Braeside Quarry* |
| *PE–3* | *H&H Aggregates Co. Ltd. – Clay Bank Quarry* |

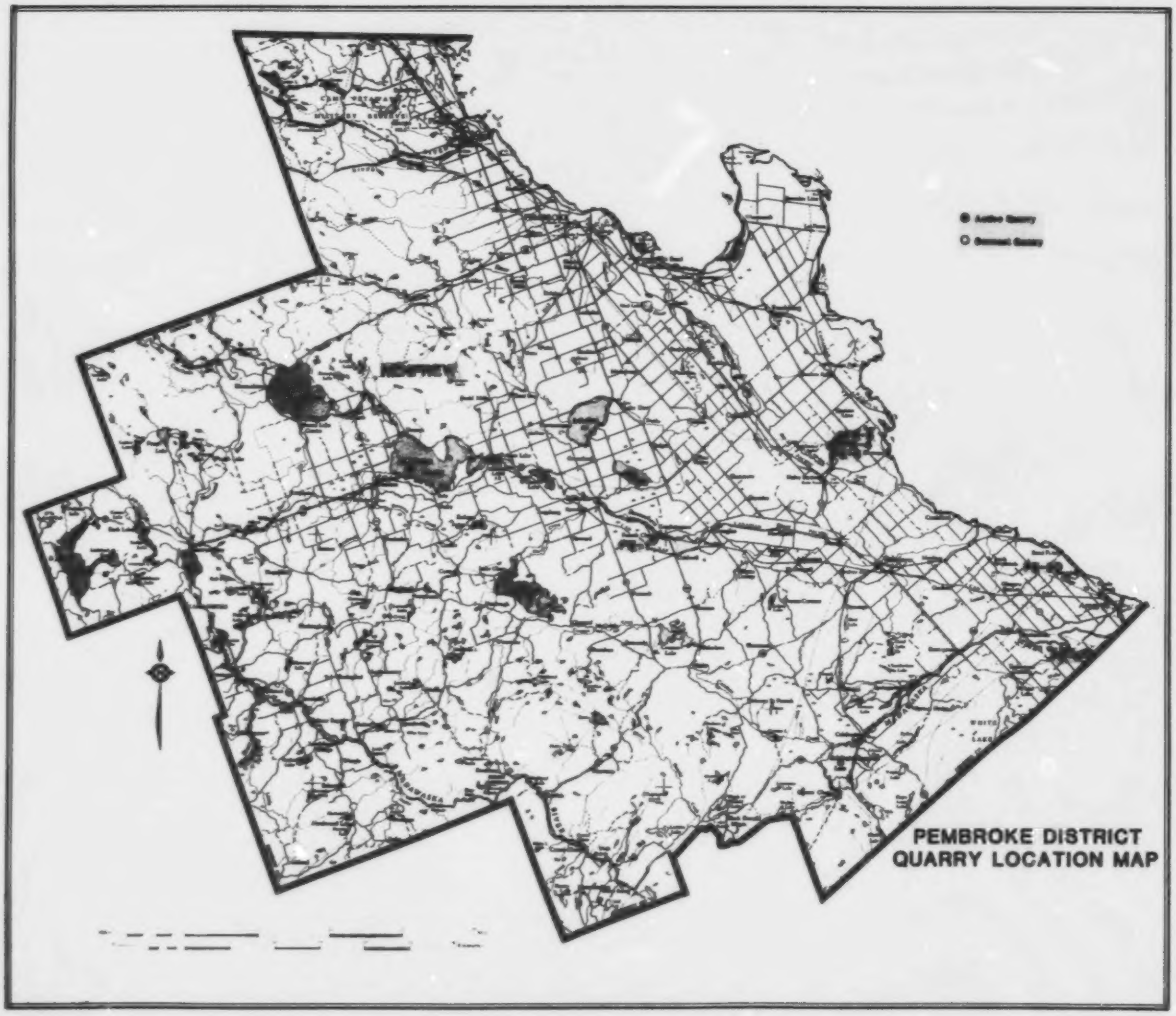


**Figure PE–0–1. PEMBROKE DISTRICT QUARRY LOCATION MAP.**

| | |
|---|---|
| *PE-4* | *Timminco Limited – Haley Station Quarry No. 1* |
| *PE-5* | *Timminco Limited – Haley Station Quarry No. 2* |
| *PE-6* | *Timminco Limited – Haley Station Plant* |

## REGIONAL GEOLOGY

Pembroke District extends westward from the Ottawa River between Arnprior and Deux Rivieres. The main geomorphic features in this district include the Ottawa Valley to the north and east, and the Precambrian highlands of the Canadian Shield within which the limited Paleozoic outcrops occur.

Glacial overburden varies considerably from nearly absent over the Precambrian highlands, to thick clay deposits along parts of the Ottawa Valley.

Large-scale normal faults trend northwest-southeast across the Pembroke District (Russell and Williams, 1985a-c, Williams, in prep), and the Paleozoic strata occur in well defined down-dropped fault blocks which had protected the enclosed strata from erosion. Although bedrock exposures are generally limited, drillhole data confirm the presence of many of these faults (Williams, in prep). Smaller-scale faults are common throughout the region, many of which are exposed in the quarries.

### PROTEROZOIC

Rocks of the Proterozoic-age/Grenville supracrustal sequence underlie the southeastern part of Pembroke District and unconformably overlie Middle Precambrian metasediments and intrusive rocks exposed to the northwest (Lumbers, 1982). The Grenville/Middle Precambrian unconformity extends southwest from Pembroke Township, southeast of the City of Pembroke.

The supracrustal metasedimentary sequence begins at the unconformity with a basal arkose, followed by a mafic metavolcanic and clastic metasedimentary sequence with subordinate marble, that extends from Renfrew to Bancroft. Southeast of this belt, carbonates become more common and purer. The grade of metamorphism varies from medium to high, mostly in the middle to upper almandine-amphibolite facies. Sedimentary structures in the carbonates have been eliminated, while those in the clastic metasediments are frequently preserved.

The marble units in the southeastern part of Pembroke District vary from a few metres to 1-3 km wide and up to 10 km in length. The smallest belts commonly consist of a single marble unit, often containing large amounts of mica, quartz and other siliceous minerals indicating a very impure limestone or lime-mud as primary sediment. The dominant trend of the marble belt is northeastward. The marbles, together with the quartzofeldspathic gneisses and metavolcanics, were subject to the Grenville Orogeny (950 m.y.) and as a result are recrystallized and complexly refolded.

### PALEOZOIC

The Paleozoic strata underlying Pembroke District consist of Lower to Middle Ordovician carbonate and clastic strata (*see* Figure CP-0-2, Carleton Place District). The following formations occur within this district (in ascending order): the March and Oxford Formations of the Beekmantown Group; the Rockcliffe Formation and the Shadow Lake, Gull River and Bobcaygeon Formations of the Ottawa Group.

The Lower Ordovician Beekmantown Group consists of two formations: the March and overlying Oxford Formations. The March Formation consists of alternating beds of quartz-rich sandstone and dolostone with gradations between the two rock types. Most common are fine-crystalline dolostones consisting of up to 50% medium- to coarse-grained, well-rounded quartz grains, which "float" in the dolostones. The formation thickens from its erosional edge to an average thickness of 20 m in the Ottawa area.

The March Formation has been quarried extensively to the southeast in Carleton Place District over the years. Large blocks of sandy dolostone were utilized in the construction of the Rideau Canal system in the 1830s. Dolostone and sandy dolostone beds were also quarried for building and ornamental stone. In addition to being a source for crushed stone, in recent years the sandy dolostone beds have proven to be an excellent source of skid-resistant aggregate (Rogers, 1980).

The Oxford Formation consists of grey-brown, fine-crystalline, medium- bedded dolostones which may vary from microcrystalline to medium-crystalline and occur in thin- to thick-bedded intervals. Scattered, coarse-grained quartz sand and sandy interbeds (up to 30 cm thick) are present in the lower part of the formation. Calcite-filled vugs, of varying sizes, are common in most intervals; small, white chert nodules are less common. The lower contact of the Oxford Formation is placed at the top of the uppermost sandstone bed in the underlying March Formation (Williams, in prep). The formation maintains an average thickness of 60 m in Carleton Place District, although it does thin northwestward into the Pembroke District.

Unconformably overlying the Beekmantown Group is the Middle Ordovician Rockcliffe Formation. The Rockcliffe Formation is subdivided into two members (Williams, in prep), a lower clastic and an upper carbonate member (Figure CP-0-2). The light grey to green-grey, fine-grained, thin- to thick-bedded, commonly crossbedded, quartz sandstone of the lower member is interbedded with olive green to grey (rarely maroon), laminated shale which contains numerous burrows. The upper St. Martins Member does not occur in Pembroke District.

The Ottawa Group consists of five formations, of which only the Bobcaygeon Formation is utilized by the limestone industry in Pembroke District. The Bobcaygeon Formation overlies the Gull River Formation and consists of limestone with shale partings and interbeds of varying amount. Three members have been identified in the Bobcaygeon Formation (Williams, in prep); the middle member is characterized by substantially more shale interbeds than the lower and upper members. The lower member consists of light grey, microcrystalline to fine–crystalline, thick– to massive–bedded limestone, with interbedded intervals of fine– to medium–grained calcarenites. Black chert nodules are common in some beds. Shale partings are very thin, and are not present between every bed. The middle member consists of grey, thin– to medium–bedded, fine– to medium–crystalline limestone and fine– to coarse–grained calcarenite, interbedded with shale beds up to 2 cm thick. The upper member, which is rarely exposed, consists of grey, fine– to medium–crystalline, thin– to medium–bedded limestone, with rare, thin shale partings. The formation is about 95 m thick, with the lower, middle, and upper members maintaining thicknesses of 30, 25 and 40 m, respectively.

Several quarries are entirely within the lower member of the Bobcaygeon Formation, including three in the Pembroke District: the Fourth Chute Quarry (PE–1), the Braeside Quarry (PE–2), and the Clay Bank Quarry (PE–3).

## LIMESTONE INDUSTRIES

The limestone industries in the Pembroke District are aggregate, metallurgical stone and lime. The 1986 Ontario Mineral Score reports aggregate and metallurgical stone production in 1985 to be in the order of 283,000 tonnes, used in the construction industry as road, asphalt and concrete aggregate and as feed for Timminco's magnesium production plant. Production came primarily from Smiths Construction Co. Ltd. (PE–2) and the two quarries operated by Timminco Ltd. (PE–4, PE–5). The Fourth Chute Quarry (PE–1) and the Clay Bank Quarry (PE–3) also produce on an intermittent basis, reporting production of less than 50,000 tonnes per year. Almost all of the stone produced by the Haley Station No. 1 and No. 2 quarries is consumed internally by Timminco for the production of magnesium. The small amount of stone not consumed internally is a by–product of the processing plant and is marketed for refractory purposes, agricultural stone or terrazzo chips.

Lime production in the District as reported in the 1986 Ontario Mineral Score was about 44,000 tonnes and is assumed to be a by–product of Timminco magnesium processing plant. In 1985 Timminco produced about 8,400 tonnes of magnesium metal at their Haley Plant ("Ontario Mineral Score", Ontario Ministry of Northern Development and Mines, 1986).

## PE–1 FOURTH CHUTE QUARRY

### LOCATION AND OWNERSHIP

This old quarry, located just south of the Fourth Chute on the Bonnechere River, in Lot 8, Concession 15, Grattan Township, Renfrew County (Figure PE–1–1), has recently been re–opened with the excavation of a lower lift into the original floor. The quarry is operated by Bromley Township on a demand basis and the aggregate produced is used by the surrounding townships.

### GEOLOGY

The 8.5 m deep quarry exposes limestones of the Middle Ordovician Bobcaygeon Formation. The presence of black chert nodules in the interbedded coarse–grained calcarenites and microcrystalline limestones suggests that these strata may be in the lower member of the formation. Minor east–west trending faults were observed on the northeast face; displacements were minor and never greater than 0.5 m on a single fault plane. Glacial overburden around the old quarry is approximately 1 m thick.

### REFERENCES

Goudge, 1938, p.165–166
Satterly, 1945

### MAPS

Russell and Williams, 1985b, O.G.S. Map P.2729

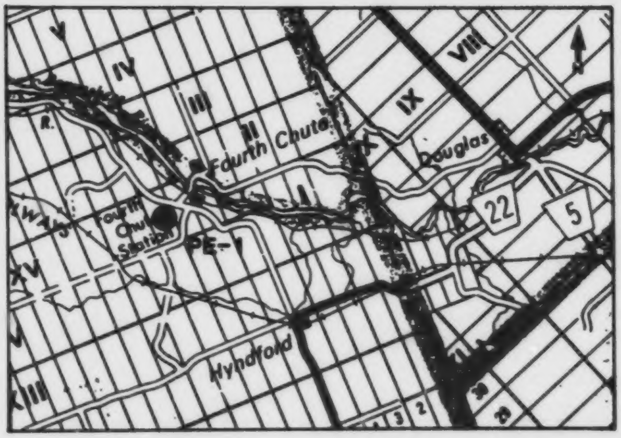


Figure PE–1–1. LOCATION MAP FOR FOURTH CHUTE QUARRY.

## PE-2 SMITHS CONSTRUCTION CO. LTD. — BRAESIDE QUARRY

### LOCATION AND OWNERSHIP

The Braeside quarry is located about 7 km northwest of Arnprior, in Lots 16 and 17, Concession A, McNab Township, Renfrew County (Figure PE-2-1) and is owned and operated by Smiths Construction Co. Ltd.

The quarry property covers an area of 80.0 ha and is not designated under the Pits and Quarries Control Act. The property was first opened in the 1930s to supply sand and gravel and in the 1950s was purchased by Smiths Construction Co. Ltd. The property was opened as an aggregate quarry in 1973 to supply concrete stone for the construction of the Arnprior hydro-electric dam. The quarry currently supplies a company-owned 5,000 lb. asphalt batch plant located in Renfrew, and much of the balance of the annual production of the Braeside quarry is used to supply company construction projects. The company also does custom crushing for various concrete plants in the area, supplying all materials. The National Research Council Canada test results on stockpiled material indicates that the stone has an extremely low expansion rate.

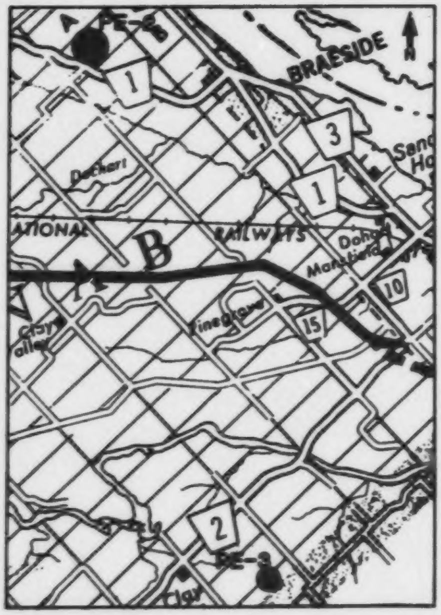


Figure PE-2-1. LOCATION MAP FOR BRAESIDE QUARRY.

### GEOLOGY

The 8.1 m deep quarry exposes very fine-crystalline, medium- to thick-bedded limestones of the lower member of the Bobcaygeon Formation. Glacial overburden around the quarry varies from 0.5 to 2 m in thickness.

#### Geological Section

| | Thickness |
|---|---|
| *UNIT 1 Bobcaygeon Formation, lower member* | *8.1m* |
| Limestone: medium-grey, rarely dark grey, weathers light grey to grey-brown at top; very fine crystalline, with rare medium-crystalline beds; medium to thick bedded with intervals of thin-bedded, shaly limestone; some beds contain intraclasts of microcrystalline limestone; moderately fossiliferous, especially with large colonial corals. | |
| *Total thickness* | *8.1m* |

### QUARRY OPERATION

The disturbed area of the quarry is currently about 3.5 ha with a single lift of 8.5 m. Overburden has been stripped over an area of about 6 ha.

All drilling and blasting is contracted; a 1.2 m x 1.5 m drill pattern with 38.5 mm diameter blast holes is used on front holes, while a 1.8 m x 2.4 m pattern is used for deep cut blasts on the back holes.

Recent alkali-aggregate reactivity tests of the National Research Council Canada on stockpile material revealed virtually no evidence of any expansion due to alkali-aggregate reactivity.

### PROCESSING

Smiths Construction Co. Ltd. owns three complete portable crushing systems which are available for custom crushing projects and include the following:

#### Primary Crushers

1 – Pioneer 30 in. x 42 in. jaw
1 – Cedarapids 30 in. x 42 in. jaw
1 – Cedarapids 24 in. x 36 in. jaw
1 – Cedarapids 855 Super Commander
1 – Cedarapids 877 Commander
1 – Pioneer 369 Triple Roll
1 – Cedarapids Impeller

#### Screening Plants

2 – 5 ft. x 16 ft. Assinck Bros.
Various stackers from 50 ft. to 120 ft.

### PRODUCTS

6 in. Crusher Run
3 in. Crusher Run
7/8 in. Class "A"
5/8 in. Class "A"
Concrete Stone
Septic Stone

### REFERENCES

Hewitt, 1964a, p. 36–37

Steele and Sinclair, 1971
Williams, in prep, Appendix 1 – Section LQ AR-5

### MAPS

Lumbers, 1982, OGS Map 2462
Williams, Wolf and Rae, 1984, OGS Map P.2726

## PE-3 H&H AGGREGATES CO. LTD. — CLAY BANK QUARRY

### LOCATION AND OWNERSHIP

This quarry, located 6 km southwest of Arnprior in Lot 1, Concession 9, McNab Township, Renfrew County (Figure PE-3-1), is operated intermittently by H&H Aggregates Co. Ltd.

### GEOLOGY

The 17.4 m deep quarry, which extends southward into an east-west trending bluff, exposes limestones of the lower member, Bobcaygeon Formation. The limestones are generally medium to thick bedded, microcrystalline to fine crystalline, and are interbedded with thinner-bedded, shaly limestones. Glacial overburden at the top of the quarry is between 1 and 3 m thick.

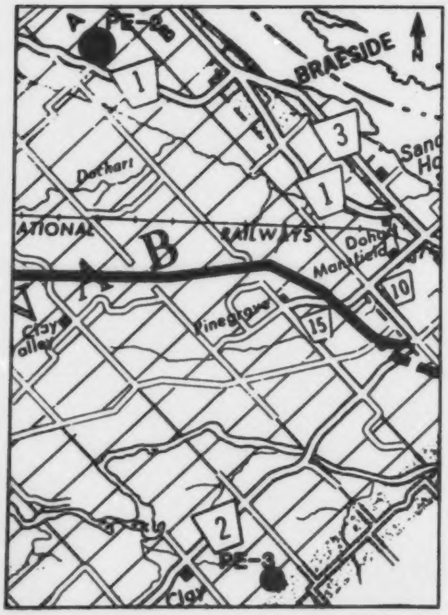


**Figure PE-3-1. LOCATION MAP FOR CLAY BANK QUARRY.**

### Geological Section

*Thickness*

*UNIT 8 Bobcaygeon Formation, lower member* *0.5m*

Limestone: light to medium grey, weathers light brown; fine to medium crystalline; thin bedded, with thin shale partings between beds; fossiliferous with abundant brachiopods.

*UNIT 7 Bobcaygeon Formation, lower member* *2.2m*

Limestone: light grey, weathers light brown; fine to medium crystalline; medium bedded, with thin shale partings between beds.

*UNIT 6 Bobcaygeon Formation, lower member* *1.3m*

Limestone: light grey, weathers light brown; fine to coarse crystalline to calcarenitic; thin- to medium-bedded intraclasts of light grey, microcrystalline limestone in lower beds.

*UNIT 5 Bobcaygeon Formation, lower member* *3.1m*

Limestone: medium grey, weathers same; microcrystalline to very fine crystalline; thin bedded with irregular shale partings between beds; small calcite crystals common, "birdseye" texture; fossiliferous, with colonial corals common.

*UNIT 4 Bobcaygeon Formation, lower member* *2.4m*

Limestone: light to medium grey, weathers light grey; microcrystalline to very fine crystalline; thin to medium bedded with thin shale partings; small calcite crystals common, "birdseye" texture; fossiliferous, with ostracods and colonial corals most common.

*UNIT 3 Bobcaygeon Formation, lower member* *4.4m*

Limestone: medium grey, weathers same; microcrystalline to fine crystalline; thin to medium bedded, with shale partings common between beds; light grey, microcrystalline limestone intraclasts common in some beds; fossiliferous, with colonial corals most abundant.

*UNIT 2 Bobcaygeon Formation, lower member* *1.0m*

Limestone: medium grey, weathers same; microcrystalline to very fine crystalline; medium bedded with sharp planar contacts.

*UNIT 1 Bobcaygeon Formation, lower member* *2.5m*

Limestone: medium grey, weathers same, microcrystalline to fine crystalline; medium bedded with shale partings common between beds; fossiliferous with colonial corals most abundant.

*Total thickness* *17.4m*

### REFERENCES

Williams, in prep, Appendix 1 – Section LQ AR-4

### MAPS

Williams, Wolf and Rae, 1984, OGS Map P.2726

## PE-4 TIMMINCO LIMITED — HALEY STATION QUARRY NO. 1

### LOCATION AND OWNERSHIP

Timminco Metals, a division of Timminco Limited, operates two dolomitic marble quarries and a magnesium reduction and extrusion plant at Haley, Ontario. The quarries and plant are located on Lot 20, Concessions 5 and 6, Ross Township, Renfrew County immediately north of

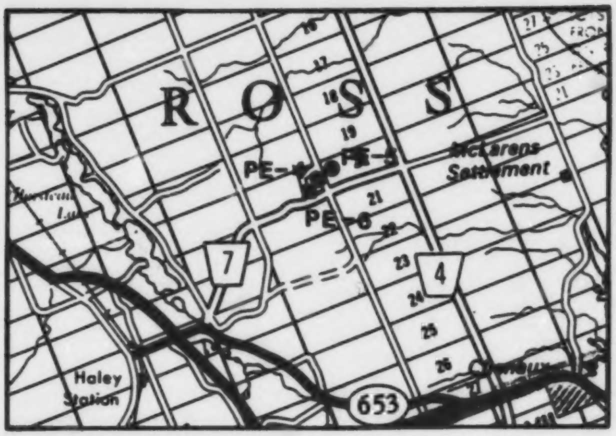


Figure PE-4-1. LOCATION MAP FOR HALEY STATION QUARRY NO. 1.

Highway 653, at the intersection of old Highway 17, 4.56 km east of Haley Station (Figure PE-4-1).

This historic quarry property first reported production around the turn of the century providing a high quality building stone that can be seen today in homes and other buildings in the district. During the period from 1910 to about 1939, the quarry saw sporadic production of building stone and/or construction aggregate but it was not until the onset of World War II that the quarry property realized its full potential as a source of raw material for production of magnesium.

### GEOLOGY

This quarry exposes a metallurgical grade, very coarse crystalline, white, Grenville dolomitic marble which strikes northerly across the property and dips 55°E. The high purity stone occupies a zone about 75 m wide and is banded on either side by chemically impure dolomitic marble containing quartz and masses of amphibolite.

### QUARRY OPERATION

The quarry occupies an area of approximately 4 ha and is only operated during the summer months. The quarry has been developed on four 6 m benches with production being derived on a selected basis from the current working face. A track mounted Sullair percussion drill is used to drill 7.6 cm diameter blast holes on a 1.2 m x 1.2 m pattern to a depth equal to the bench height. The holes are charged with Tovex at a rate of 25 kg per hole. Blasting is done on two-week cycles and each blast produces about 3,000 tonnes of broken rock, which is loaded at the face into 20-tonne Terex trucks by a 2.5 yd. Dominion shovel and transported to the processing plant.

### PROCESSING

The quarry run material is trucked to the Timminco Plant (PE-6) for processing.

### REFERENCES

Parks, 1912
Goudge, 1938, p.168
Satterley, 1945, p.66
Hewitt, 1964a, p.17
Hewitt, 1964b, p.75
Storey and Vos, 1981, p. 69-70

## PE-5 TIMMINCO LIMITED — HALEY STATION QUARRY NO. 2

### LOCATION AND OWNERSHIP

In 1968 Timminco opened a second quarry, about 300 m northeast of the original quarry on Lot 20, Concession 6, Ross Township, Renfrew County (Figure PE-5-1). This second quarry currently provides most of the stone for the magnesium operation.

### GEOLOGY

The quarry currently comprises an area of approximately 4 ha and has exposed a metallurgical grade dolomitic marble which strikes N10°E and dips 50°E. The high purity stone, which is similar to that exposed in the original quarry, occupies a zone up to 60 m wide and is bounded on one side by a very siliceous impure dolomitic marble. Thick overburden impedes expansion eastward.

### QUARRY OPERATION

The quarry operates year-round and is currently being developed on two benches with production being derived from a 7.6 m working face. Drilling is conducted using a

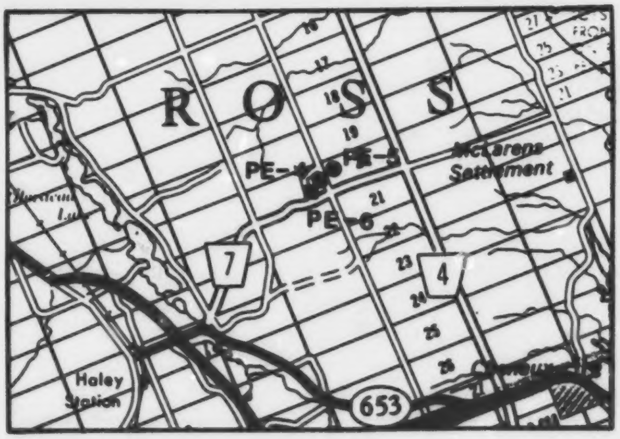


Figure PE-5-1. LOCATION MAP FOR HALEY STATION QUARRY NO. 2.

Sullair track mounted drill. Blast holes are approximately 9 cm in diameter and are drilled to a depth of about 9.6 m or 1 m below the quarry floor. The holes are drilled on a 2.1 m x 2.1 m pattern which extends 6.5 m from the working face. The holes are loaded with Tovex at a rate of 25 kg per hole. Blasting is done twice a month, with about 6,000 tonnes broken with each blast. Secondary breaking, if required, is by drop ball. The broken rock is loaded at the face into 20-tonne Terex trucks by either a 1 yd. Clark front-end loader or a 2.5 yd. Dominion shovel and transported to the processing plant.

### PROCESSING

The quarry run material is trucked to the magnesium plant (PE-6) for processing.

### REFERENCES

Storey and Vos, 1981, p.69-70

## PE-6 TIMMINCO LIMITED — HALEY STATION PLANT

### LOCATION AND OWNERSHIP

Timminco Limited operates a magnesium reduction and extrusion plant at Haley, Ontario (Figure PE-6-1).

### PROCESSING

The Haley plant uses the silicothermic reduction process (Figure PE-6-2). Under this process magnesium is produced from calcined dolomite, under vacuum at high temperature, using silicon as a reducing agent. The process and the high quality of raw materials used by Timminco allow it to produce magnesium of the highest purity, which has important applications in the nuclear energy and the pharmaceutical industries. Timminco is also a major supplier of high purity magnesium to the chemical reduction markets where it is used as a reducing agent in the production of a number of metals including uranium, beryllium, titanium and zirconium.

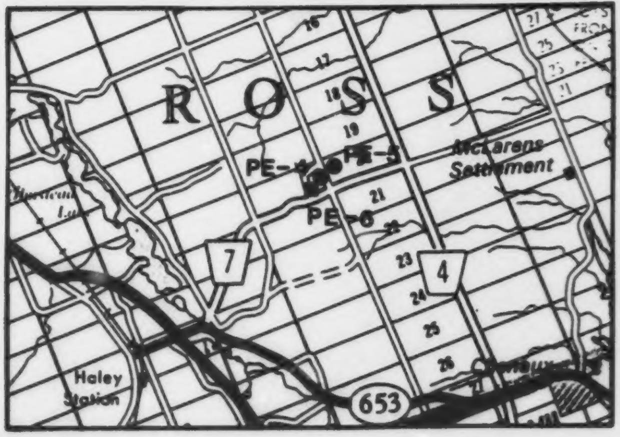


Figure PE-6-1. LOCATION MAP FOR HALEY STATION PLANT.

The first stage in the production process at Haley is the quarrying of dolomite. Approximately 125,000 tonnes are extracted each year from the on-site quarries. The dolomite is crushed, then calcined by burning off carbon dioxide in rotary kilns. This calcined dolomite is then pulverized before being mixed with ferrosilicon and a catalyst. The resultant mixture is then briquetted.

The next stage in the process is reduction, which begins with the mechanical loading of briquettes into nickel-chrome alloy retorts in reduction furnaces which have an operating temperature of about 1,200°C. The reduction operation is a batch process, with charging and discharging of furnaces occurring in regular 8-hour cycles. Magnesium condenses into "crowns", which are removed from the furnace at the end of the process and melted in crucibles. The liquid metal is then cast into ingots and billets of magnesium metal or magnesium alloys, as required, ready for sale or for use in the extrusion plant.

Approximately 10% of the magnesium production is used at Haley in a secondary manufacturing operation which extrudes magnesium into higher value-added finished products, comprising many structural shapes such as angles, channels and tubes, as well as exclusive shapes for special products such as water heater anodes and luggage frames.

In response to the demands of the aluminum industry, Timminco designed and implemented during 1985 its own system of producing static castings of massive magnesium ingots. These 125 kg and 250 kg castings result in more efficient handling operations as well as improved magnesium recovery for customers producing aluminum-magnesium alloys.

### RAW MATERIALS

The principal raw materials used in the production of magnesium are ferrosilicon and dolomite. The company estimates that its Haley plant is the largest North American consumer of ferrosilicon, which it obtains from its ferrous metals facility at Beauharnois, Quebec. High quality dolomite is obtained from two open-pit quarries on the Haley site. It is the company's view that dolomite deposits at Haley will suffice for at least 25 years at present consumption levels.

The Haley plant's other major requirement is energy. The principal energy source is natural gas which is used in kiln firing, the silicothermic reduction process and melting operations. Electricity is also used in the production process.

Timminco currently purchases strontium carbonate, the primary raw material used to produce strontrium

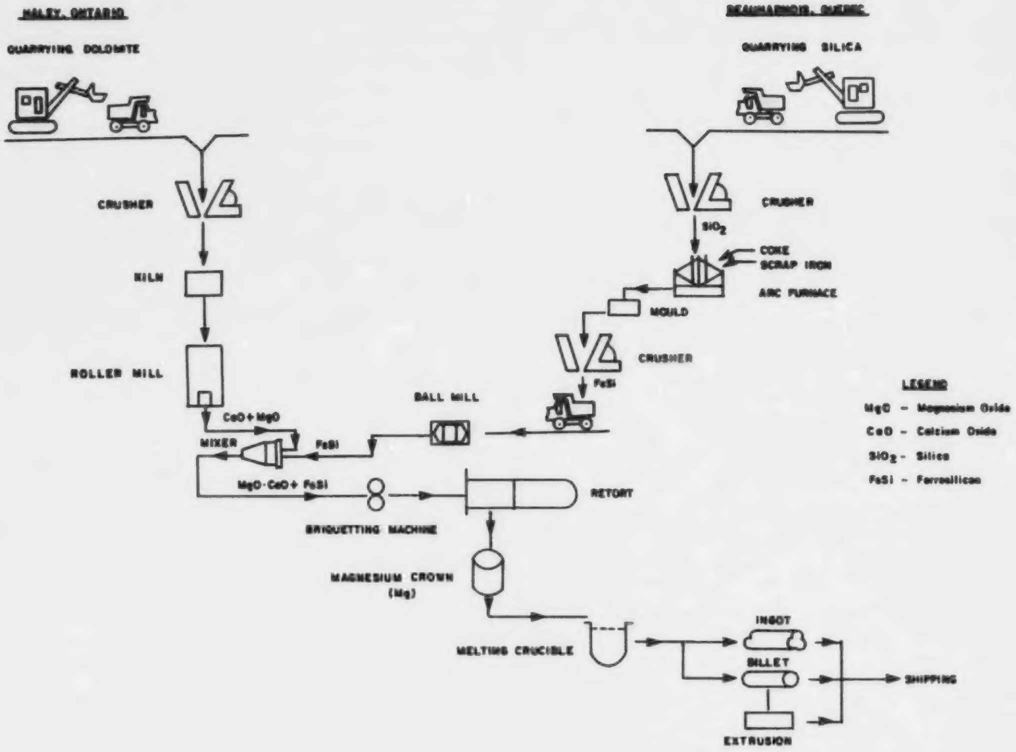

HALEY, ONTARIO
QUARRYING DOLOMITE
CRUSHER
KILN
ROLLER MILL
CaO + MgO
MIXER
FeSi
MgO·CaO + FeSi
BRIQUETTING MACHINE
BALL MILL
RETORT
MAGNESIUM CROWN
(Mg)
MELTING CRUCIBLE
INGOT
BILLET
EXTRUSION
SHIPPING
BEAUHARNOIS, QUEBEC
QUARRYING SILICA
CRUSHER
SiO2
COKE
SCRAP IRON
ARC FURNACE
MOULD
CRUSHER
FeSi
LEGEND
MgO – Magnesium Oxide
CaO – Calcium Oxide
SiO2 – Silica
FeSi – Ferrosilicon

**Figure PE-6-2. PROCESS FLOW SHEET FOR HALEY STATION PLANT, ILLUSTRATING THE INTERRELATIONSHIP BETWEEN THE PLANTS AT HALEY, ONTARIO AND BEAUHARNOIS, QUEBEC.**

metal, from a limited number of offshore suppliers. Strontium carbonate is derived from the concentration and conversion of high–quality celestite. In November 1985, Timminco was granted a licence by the Province of Nova Scotia to carry out a work program to develop celestite ore deposits in Cape Breton County. The Division is continuing its work program to determine the economic viability of the orebodies.

### KILN OPERATION

The −1 in. +1/4 in. product is discharged from the storage bins as required and calcined in either of two gas–fired rotary kilns; both have provisions for standby oil firing. The kilns are 7 ft. and 8 ft. in diameter and 120 ft. and 153 ft. long, respectively. Both have rotary coolers which cool the lime to approximately 200°C before it is conveyed to storage bins. The calcined material is crushed in a Raymond roller mill to −10 mesh, with the dominant fraction being −100 mesh.

# Part 2
# Northern Ontario

Included in the Northern Ontario Region are the lime/cement plants at Spragge in Blind River District, and the limestone quarries of Cobalt, Espanola and Moosonee Districts.

Eighteen quarries in the Northern Ontario Region are documented in the quarry inventory (Appendix IV, Volume I); three are currently active, four report intermittent production and the balance represent past-producing quarries.

The principal limestone industries in Northern Ontario Region are limestone aggregates and metallurgical stone, with minor production of agricultural lime and building stone. The Reiss Lime Company of Canada Ltd. plant at Spragge produces high calcium lime from limestone quarried in the United States, and slag cement from slag produced by Algoma Steel Corp. Ltd. at Sault Ste. Marie.

Stone production for 1986 in District of Manitoulin totalled approximately 1.2 million tonnes, (Ontario Mineral Score, 1987) comprised mainly of aggregate and metallurgical stone and small tonnages of building stone.

Production in 1986 of metallurgical flux and aglime from Dymond Clay Products Ltd. Quarry (CO-4), in Cobalt District, was reported at 130,000 tonnes (Owsiacki, 1987).

# Espanola District

## INTRODUCTION

The active and intermittently active quarries in Espanola District were visited during the study, and include the following:

- *ES–1* *Standard Aggregates Inc. – Manitoulin (Meldrum Bay) Quarry (active)*
- *ES–2* *Hercules Ornamental Stone – Foxey Quarry (intermittent)*
- *ES–3* *Cup and Saucer quarry (intermittent)*

## PALEOZOIC GEOLOGY

The Paleozoic strata of Espanola District are confined to Manitoulin Island and the smaller adjacent islands in northern Lake Huron (Figure ES–0–1). Located along the northern rim of the Michigan Basin, the exposed Ordovician and Silurian stratigraphic succession (Figure ES–0–2) closely resembles the sequence of the Niagara Escarpment to the south. Glacial cover on Manitoulin Island is generally thin, creating large areas of bedrock exposure. Quarry development on Manitoulin Island (Figure ES–0–1) is currently restricted to a major operation near Meldrum Bay (ES–1), a small ornamental stone operation near Foxey (ES–2), and a wayside quarry at the Cup and Saucer (ES–3). The potential for additional development on Manitoulin Island and nearby St. Joseph Island is high, especially as these islands are adjacent to Great Lakes shipping routes.

The Paleozoic succession in the Espanola District consists of Ordovician and Silurian sedimentary rocks which include thick limestone and dolostone intervals. Recent revisions to the nomenclature that have been proposed by Johnson and Telford (1985a,b,c,d) are used in this report.

The oldest unit exposed on the islands north of Manitoulin Island is a clastic sequence of conglomerates, sandstones, and shales, similar to the Shadow Lake Formation of Central Ontario. A unit of older sandstone and dolostone occurs at the base of the Paleozoic sequence in deep drillholes on Cockburn Island (Wolf, 1986) and St. Joseph Island (Johnson et al., 1985). No bedrock exposures of these dolostones have yet been reported.

The overlying Middle Ordovician limestones superficially resemble the Simcoe Group of Central Ontario, but the limited exposures of these strata in the district reveal a different succession which has yet to be studied in detail. North of Manitoulin Island are smaller islands which are underlain by these limestones and may have some potential for quarry development. The predominantly shale–rich Upper Ordovician strata of the Blue Mountain and Georgian Bay Formations (Figure ES–0–2) outcrop in the northern Lake Huron region.

The Lower Silurian on Manitoulin Island consists of the Manitoulin Formation and the overlying Cabot Head Formation, characterized by thin–bedded dolostones and red shales, respectively. A small ornamental stone operation, the Foxey Quarry of Hercules Ornamental Stone (ES–2) extracts glacially polished dolostones from the Manitoulin Formation.

The Middle Silurian sequence (Figure ES–0–2) includes the following (in ascending stratigraphic order): the Dyer Bay Formation – a thin, fossiliferous dolostone; the Wingfield Formation – a green shale and shaly dolostone; the St. Edmund Formation – predominantly a thin–bedded, microcrystalline dolostone; the Fossil Hill Formation – a thin–bedded, fossiliferous, chert–rich dolostone; and the Amabel Formation – a massive–bedded, evenly textured dolostone. The wayside quarry at the Cup and Saucer (ES–3) is excavated into the upper part of the St. Edmund Formation, with a thin interval of the overlying Fossil Hill Formation present as a caprock in the quarry. The large quarry near Meldrum Bay (ES–1), operated by Standard Aggregates Inc., exposes the massive–bedded dolostones of the Amabel Formation. Crushed on–site to a variety of sizes, the stone is shipped by lake freighter to markets from the dock adjacent to the quarry. Northeast of the village of South Baymouth is the inactive Leason Quarry. This quarry was a source of Amabel Formation armour stone blocks used for the construction of the South Baymouth docks.

## ES–1 STANDARD AGGREGATES INC. — MANITOULIN (MELDRUM BAY) QUARRY

### LOCATION AND OWNERSHIP

The Manitoulin Quarry is located on the western tip of Manitoulin Island, 9 km west of the village of Meldrum Bay, in Lot 45, Concession 9, Dawson Township, District of Manitoulin (Figure ES–1–1).

The quarry is owned and operated by Standard Aggregates Incorporated, purchased in May of 1986 from Seeley and Arnill Construction Ltd., and Upper Lakes Shipping. The quarry has been in operation since 1980, supplying chemical grade stone and construction aggregate to U.S. and Canadian markets. The quarry operates on a 7 months per year basis, and all stone products are shipped by boat over an 8–month shipping season at about 25,000 tonnes per load.

### GEOLOGY

The dolostones of the Amabel Formation are excavated in a single lift of 17.8 m. Adjacent to the primary

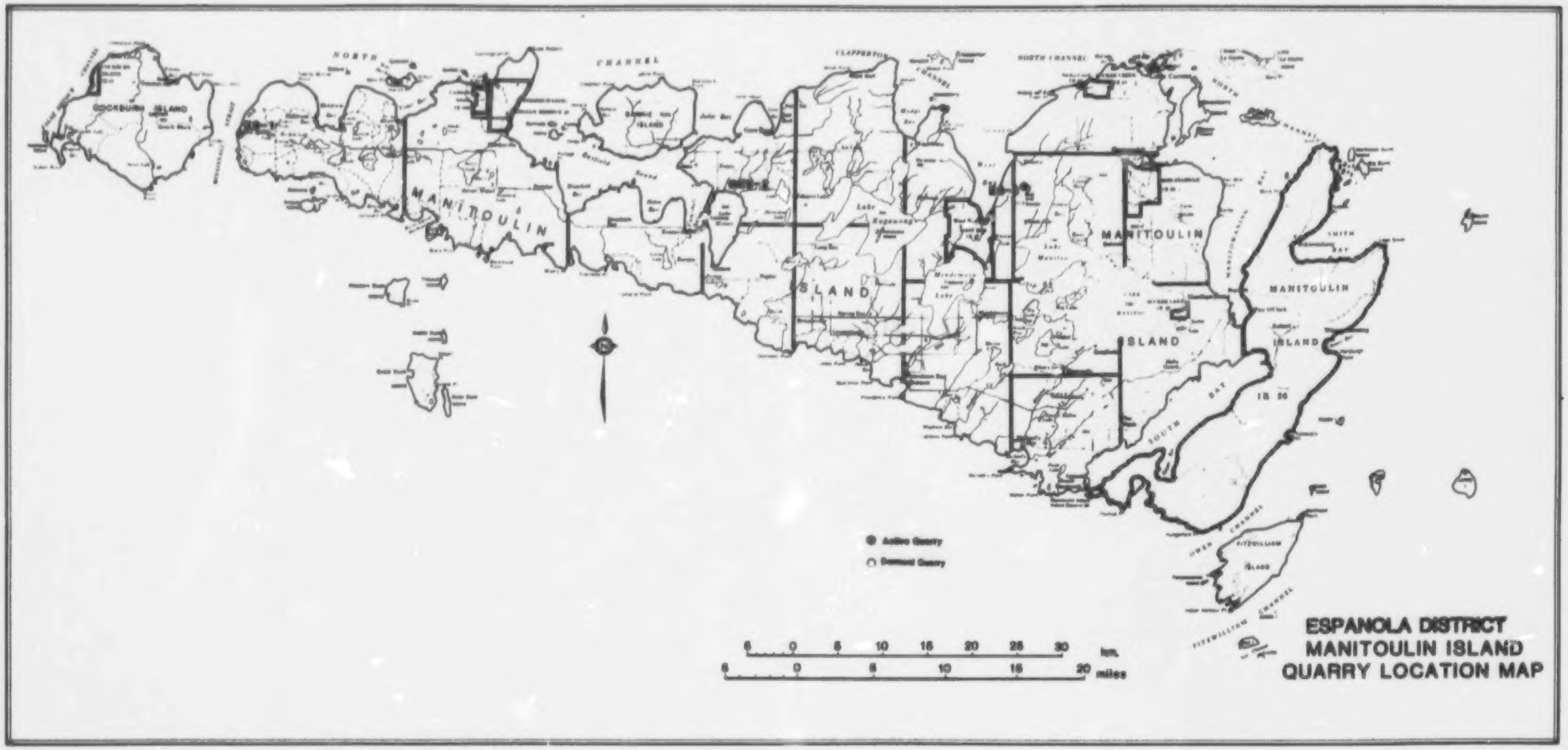
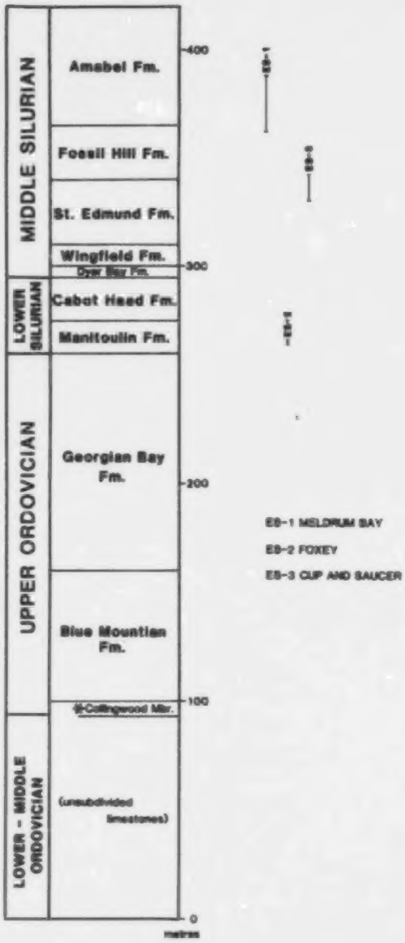

ESPANOLA DISTRICT
MANITOULIN ISLAND
QUARRY LOCATION MAP
Active Quarry
Dormant Quarry
5 0 5 10 15 20 25 30 km.
5 0 5 10 15 20 miles
NORTH CHANNEL
CHANNEL
CLAPPERTON
NORTH CHANNEL
COCKBURN ISLAND
MANITOULIN
ISLAND
MANITOULIN
ISLAND
MANITOULIN
ISLAND
SOUTH BAY
SMITH BAY
FITZWILLIAM ISLAND
FITZWILLIAM CHANNEL
OWEN CHANNEL
I.R. 26

Figure ES-0-1. ESPANOLA DISTRICT (MANITOULIN ISLAND) QUARRY LOCATION MAP.


MIDDLE SILURIAN
LOWER SILURIAN
UPPER ORDOVICIAN
LOWER - MIDDLE ORDOVICIAN
Amabel Fm.
Fossil Hill Fm.
St. Edmund Fm.
Wingfield Fm.
Dyer Bay Fm.
Cabot Head Fm.
Manitoulin Fm.
Georgian Bay Fm.
Blue Mountian Fm.
✻Collingwood Mbr.
(unsubdivided limestones)
400
300
200
100
0
metres
ES-1
ES-2
ES-3
ES-1 MELDRUM BAY
ES-2 FOXEY
ES-3 CUP AND SAUCER

N.B. : Maximum thicknesses are assumed for this section

✻ Collingwood Member of the Lindsay Formation

Figure ES-0-2. STRATIGRAPHIC COLUMN SHOWING PRINCIPAL QUARRIES OF ESPANOLA DISTRICT (MANITOULIN ISLAND).

crusher, an additional 7.2 m is exposed below the quarry floor, of which the lower 2.5 m are assigned to the Fossil Hill Formation (Figure ES-1-2).

The dolostones of the Fossil Hill Formation are primarily thin-bedded and contain significant amounts of chert and silicified fossil material. In contrast the dolostones of the Amabel Formation are thick bedded, contain virtually no chert, and are sparsely fossiliferous. Glacial overburden around the quarry varies in thickness from a few centimetres to 2.5 m.

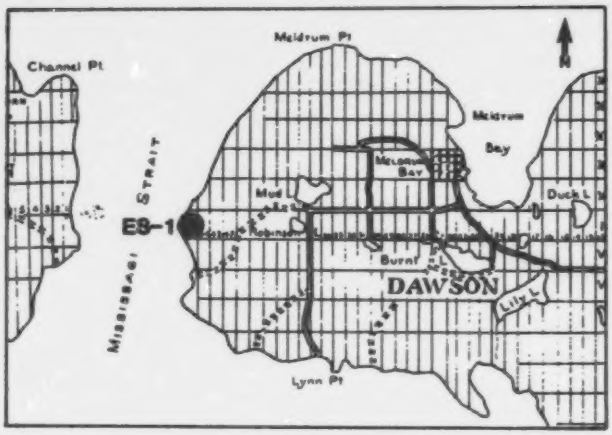

Meldrum Pt
Channel Pt
N
Meldrum Bay
Meldrum Bay
Mud L
Robinson
Duck L
ES-1
Mississagi Strait
Burnt L
DAWSON
Lily L
Lynn Pt

Figure ES-1-1. LOCATION MAP FOR MANITOULIN (MELDRUM BAY) QUARRY.

## Geological Section

*Thickness*

*UNIT 2 Amabel Formation* *22.5m*

Dolostone: blue-grey, to light grey, cream and white; weathers light grey, to light brown and tan; dominantly fine crystalline with some medium-crystalline intervals, in a very uniform texture; thick bedded (0.5-1.0 m) with sharp contacts; very rare, very thin, dark grey, shale partings present, especially in lowermost 10.0 m; small white chert nodules present in lowermost 30 cm; small vugs, commonly open, present in most beds; sparsely fossiliferous; uppermost 2 m on south and east faces extensively fractured and jointed, elsewhere a massive 1.5-2.0 m thick bed is present; lower contact of unit sharp, slightly irregular, coincident with floor of primary crusher.

*UNIT 1 Fossil Hill Formation* *2.5m*

Dolostone: light grey-brown to light grey, tan in upper 10 cm, weathers medium grey-brown; fine to medium crystalline, with patches of coarse crystalline; thin bedded (5-10 cm) with slightly undulating contacts and rare, very thin, black shale partings; very chert-rich horizons 1.5 m and 2.1 m above base of unit, with chert nodules sporadic throughout unit; very fossiliferous with silicified corals and stromatoporoids most common.

*Total thickness* *25.0m*

## QUARRY OPERATION

Overburden is removed by Cat 988B loader and Euclid 40-ton trucks for the construction of a berm along the northeast quarry boundary. The chemical grade stone is currently mined on a single lift of 17.8 m on the south and east faces, 250 m and 400 m in length respectively. A second lift of aggregate quality stone is held in reserve.

Drilling and blasting is contracted and a drill pattern of 3 m x 3.7 m is used with 11 cm diameter holes. Groundwater seepage is excessive and holes must be

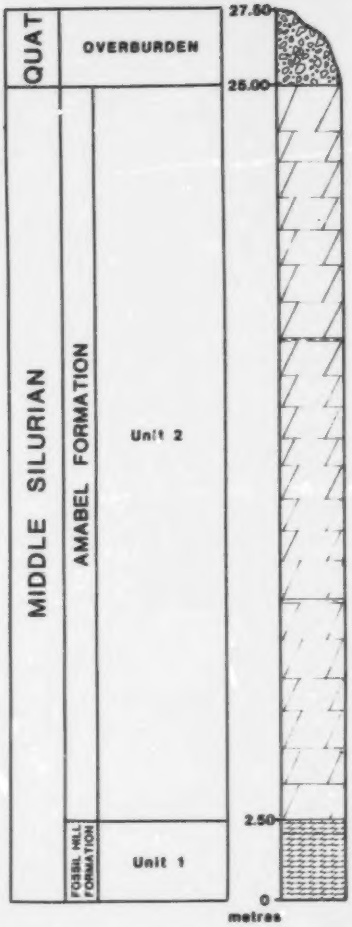


Figure ES-1-2. STRATIGRAPHIC COLUMN FOR MANITOULIN (MELDRUM BAY) QUARRY.

Photo ES-1-1. PRIMARY CRUSHER SUMP AT MANITOULIN (MELDRUM BAY) QUARRY. HAMMER HEAD INDICATES CONTACT OF FOSSIL HILL FORMATION AND AMABEL FORMATION.

pumped before explosives are loaded. A bulk mixing truck is used to load the blast holes, with hydromex slurry used as a toe charge and Amex II (AN/FO) as a column charge. Holes are primed with Pro–Core primers and initiated with primacord. Approximately 22,000 tonnes are blasted per shot.

A Cat 988B 7 yd. loader is used at the face to load trucks (two Euclid 40–ton) for a haulage distance of about 300 m. Future quarry design calls for the use of a Cat 992 loader and two 55–ton Cat trucks when the haulage distance becomes too long to supply the primary crusher at a continuous rate of 1,000 tonnes per hour with the smaller units.

## PROCESSING

The flow sheet for the plant is shown on Figure ES–1–3. Primary crushing is done with a 48 in. x 60 in. jaw, presently stationed in the centre of the quarry. The –10 in. product is carried approximately 150 m by a 36 in. conveyor belt to a stacker feeding a primary surge pile. This pile is recovered by a tunnel conveyor and sent to a Cedarapids 5 ft. x 16 ft. triple deck screen. Minus 1 in. fines from this screen are sent directly to a Granular "A" stockpile while oversize from the middle and bottom decks is sent to a secondary surge pile. Oversize from the top screen is sent to a 5 ft. Eljay Rollercone for secon-

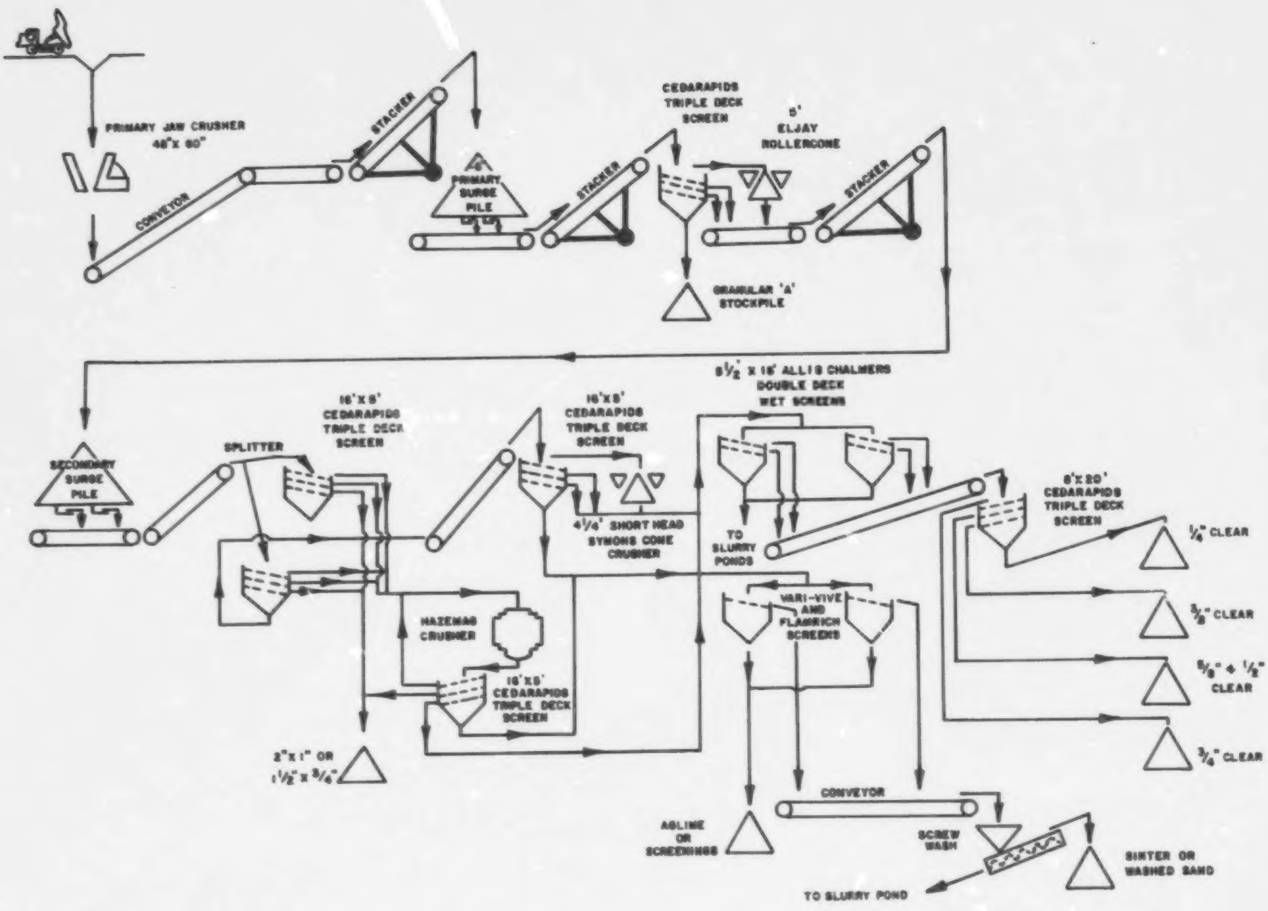

PRIMARY JAW CRUSHER
48" X 60"
CONVEYOR
STACKER
4"
PRIMARY SURGE PILE
STACKER
CEDARAPIDS TRIPLE DECK SCREEN
5'
ELJAY ROLLERCONE
STACKER
GRANULAR 'A' STOCKPILE
8½' X 16' ALLIS CHALMERS DOUBLE DECK WET SCREENS
SECONDARY SURGE PILE
SPLITTER
16'X8' CEDARAPIDS TRIPLE DECK SCREEN
16'X8' CEDARAPIDS TRIPLE DECK SCREEN
4¼' SHORT HEAD SYMONS CONE CRUSHER
TO SLURRY PONDS
8'X20' CEDARAPIDS TRIPLE DECK SCREEN
¼" CLEAR
⅜" CLEAR
⅝" + ½" CLEAR
¾" CLEAR
HAZEMAG CRUSHER
16'X8' CEDARAPIDS TRIPLE DECK SCREEN
VARI-VIVE AND FLAMRICH SCREENS
2"X1" OR 1½"X¾"
CONVEYOR
AGLIME OR SCREENINGS
SCREW WASH
SINTER OR WASHED SAND
TO SLURRY POND

Figure ES-1-3. PROCESS FLOW SHEET FOR MANITOULIN (MELDRUM BAY) QUARRY.

dary crushing to −4 in. and added to the secondary surge pile.

The secondary surge pile material is split between two Cedarapids 5 ft. x 16 ft. triple-deck screens. Oversize (+1 1/2 in.) from the top two decks of each screen is sent for tertiary crushing by a Hazemag hammer mill, while −1 1/2 in. +3/4 in. oversize from the third decks is stockpiled as a chemical stone product. Fines (−3/4 in.) from both screens are sent to a third triple-deck screen.

Oversize material from the top deck of the third screen is sent for tertiary crushing by a Symons 4 1/4 ft. short head cone crusher, the product being returned to the screen. Fines are sent to a single deck Vari-vive or Flamrich screen. Intermediate-sized material is sent to two in-series Allis-Chalmers 5 1/2 ft. x 16 ft. double deck wash screens.

Stone leaving the Hazemag hammer mill is sent to a Cedarapids 5 ft. x 16 ft. triple-deck screen. Fines are sent to the Vari-vive/Flamrich screens; oversize from the bottom deck is sent to the wash screens; −1 1/2 in. +3/4 in. stone from the middle deck goes to the chemical stone stockpile; and oversize from the top deck is recrushed by the hammer mill.

Fines from the Allis-Chalmers wash screens are sent to a settling pond. Oversize from both screens is sent to a Cedarapids 8 ft. x 20 ft. triple-deck screen, producing four clear stone products, 1/4 in., 3/8 in., 1/2 in. and 3/4 in.

Photo ES-1-2. CEDARAPIDS TRIPLE DECK SCREEN WITH ELJAY ROLLERCONE SECONDARY CRUSHER; MANITOULIN (MELDRUM BAY) QUARRY.

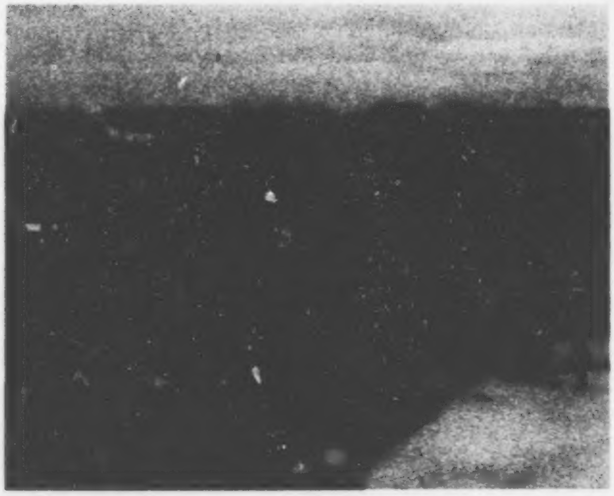


Photo ES-1-3. PRIMARY CRUSHER WITH DRILLING IN BACKGROUND; MANITOULIN (MELDRUM BAY) QUARRY.

Fines from the Vari-vive and Flamrich screens are stockpiled as a screening or aglime product. Oversize from both screens is sent to a screw crusher producing a sinter or washed sand product. Stone is blended from various stockpiles by feeders to tunnel conveyors to achieve construction specifications.

### PRODUCTS

Granular "A"
3/4 in. Clear
5/8 in. Clear
3/8 in. Clear
1/4 in. Clear
Washed Concrete Sand
Sinter Sand
Screenings
2 in. to 1 in. Chemical Grade Stone
Agricultural Lime – 10 mesh

### REFERENCES

None

### MAPS

Johnson and Telford, 1985c, OGS Map P.2667

Photo ES-2-1. TYPICAL QUARRY RUN MATERIAL AT FOXEY QUARRY.

## ES-2 HERCULES ORNAMENTAL STONE — FOXEY QUARRY

### LOCATION AND OWNERSHIP

Hercules Ornamental Stone operates this small quarry in Lot 17, Concession 5, Gordon Township, District of Manitoulin, about 1.5 km south of the hamlet of Foxey (Figure ES-2-1).

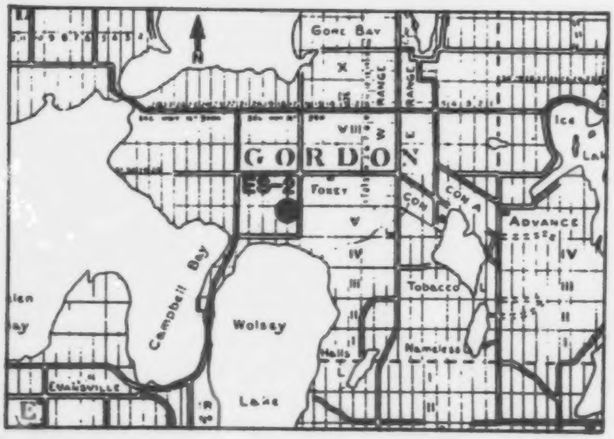

Gore Bay
GORDON
ES-2
Foxey
Advance
Tobacco
Campbell Bay
Wolsey
Lake
Ice Lake

Figure ES-2-1. LOCATION MAP FOR FOXEY QUARRY.

### GEOLOGY

The bedrock surface of the dolostones of the Manitoulin Formation at this site has been highly polished by glacial processes. The surface bed, which is usually 10–20 cm thick, is cut by saws into ornamental stone which is used primarily in home construction.

The dolostones of the Manitoulin Formation exposed at this site are blue-grey, buff weathering, fine crystalline, and thin to medium bedded. Small nodules of soft white chert are scattered throughout the beds. Up to 2 m of overburden is removed to expose the glaciated surface.

### REFERENCES

None

### MAPS

Johnson and Telford, 1985d, OGS Map P.2668

## ES-3 CUP AND SAUCER QUARRY

### LOCATION AND OWNERSHIP

Located in Lot 29, Concession 8, Bidwell Township, District of Manitoulin (Figure ES-3-1), the quarry at the Cup and Saucer is operated intermittently by the Ministry of Transportation for aggregate, most of which is used in asphalt.

### GEOLOGY

The quarry extends northward into an east–west trending escarpment and exposes 11.0 m of dolostone (Figure ES-3-2). The lower 9.5 m is assigned to the St. Edmund Formation and the overlying 1.5 m to the Fossil Hill Formation. The upper part of the quarry is generally inaccessible due to the adjacent escarpment. Overburden

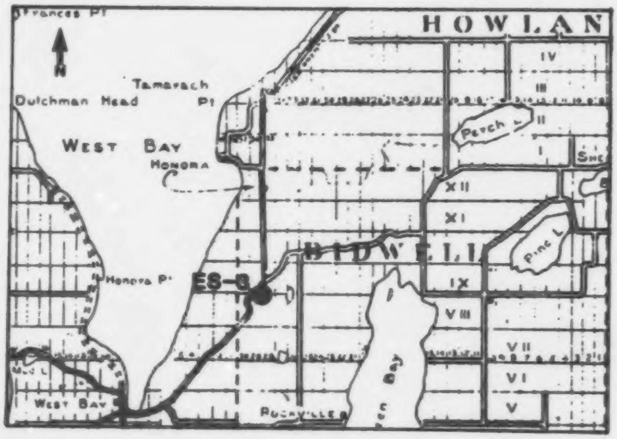

HOWLAN
Dutchman Head
Tamarack Pt
West Bay
Honora
Honora Pt
Perch L
Pine L
BIDWELL
ES-3
West Bay
Rockville

Figure ES-3-1. LOCATION MAP FOR CUP AND SAUCER QUARRY.

**Photo ES-3-1. EAST FACE AT CUP AND SAUCER QUARRY.**

along the escarpment varies from a few centimetres to 2.0 m.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 2 Fossil Hill Formation* | *1.5m* |
| Dolostone: medium grey-brown, weathering dark grey-brown; fine to medium, rarely coarse crystalline with intermixing of crystal sizes; thin bedded (5-10 cm) with thin shale partings and irregular contacts; white chert common, with both soft, chalk-like and hard, flint-like varieties; very fossiliferous, with fossils commonly silicified, corals and pentamerid brachiopods most abundant; lower contact of unit sharp and slightly irregular. | |
| *UNIT 1 St. Edmund Formation* | *9.5m* |
| Dolostone: light grey, rarely medium brown, weathers light grey to tan, rarely medium brown; very fine crystalline, rare beds of medium crystalline (sugary texture); medium bedded (10-15 cm), fine-crystalline beds commonly laminated, with sharp, planar contacts; mud cracked surfaces, muddy dolostone intraclasts, and burrows common on bedding plane surfaces. | |
| *Total thickness* | *11.0m* |

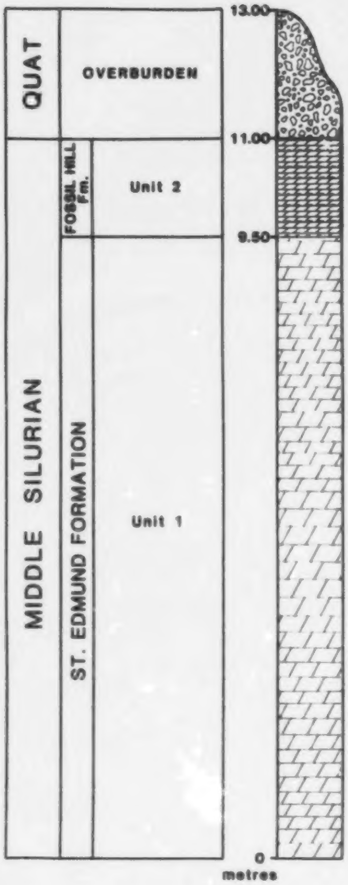


**Figure ES-3-2. STRATIGRAPHIC COLUMN FOR CUP AND SAUCER QUARRY.**

## REFERENCES

None

## MAPS

Johnson and Telford, 1985a, OGS Map P.2669

# Blind River District

## INTRODUCTION

The lime and slag cement plants of Reiss Lime Company of Canada Ltd. are located in Blind River District. There are no limestone quarries located in the district. Reiss Lime imports high–calcium limestone from quarries in Michigan.

## BL–1 REISS LIME COMPANY OF CANADA LTD. — SPRAGGE PLANT

### LOCATION AND OWNERSHIP

Reiss Lime Company of Canada Ltd. operates a 550 tonne/day high calcium lime plant and a 200,000 tonne/year slag cement plant at Spragge, Ontario on the north shore of Lake Huron. The company is jointly owned by Reiss Lime Inc. of the United States and Denison Mines Ltd. of Canada.

### PROCESSING

No details on the equipment and production process are available from the company.

### PRODUCTS

Most of the output of the lime plant is destined for the nearby uranium, nickel and copper mines and smelters at Elliot Lake and Sudbury where it is used for acid neutralization and for use in steel manufacturing at Algoma Steep Corp. Ltd. in Sault Ste. Marie.

The slag cement operation was started up in 1986, using material provided by Algoma Steel Corp. Ltd. The cement is sold under long–term contract to INCO Ltd. for use in mine backfilling operations in their Sudbury area mines.

# Cobalt District

## INTRODUCTION

The active and intermittently active quarries in Cobalt District that were visited during the study include the following:

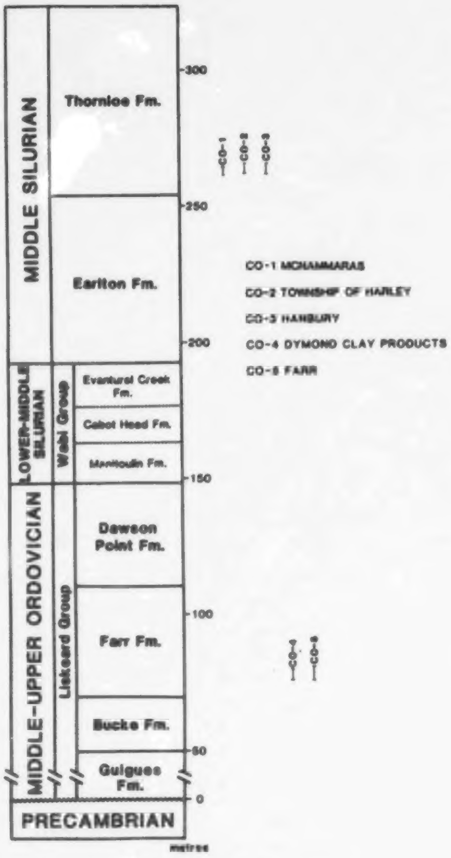
| | |
|---|---|
| *CO-1* | *Nortario Limestone Ltd. – McNammaras Quarry (intermittent)* |
| *CO-2* | *Township of Harley Quarry (intermittent)* |
| *CO-3* | *Hanbury Quarry (abandoned)* |
| *CO-4* | *Dymond Clay Products Ltd. – Bucke Quarry (active)* |
| *CO-5* | *Farr Quarry (abandoned)* |

## PALEOZOIC GEOLOGY

The Paleozoic rocks of the Lake Timiskaming outlier (*see* Figure CO-0-1 on chart in back pocket of Volume I), located around the northwestern end of Lake Timiskaming, are geologically important as they represent the only significant Paleozoic strata between northern Lake Huron and the Hudson Bay Platform. The outlier is nearly equidistant between two major depositional centres in Ontario, the Michigan Basin to the south and the Moose River Basin to the north, and occupies a fault-controlled depression (a graben) that includes Lake Timiskaming and an area extending northwest from the lake. This region has been called the Lake Timiskaming Rift Valley (Lovell and Caine, 1970) and is the northerly extension of the Ottawa Valley structural province. The major geomorphic feature within the graben is an easterly-facing escarpment of Silurian strata (Russell, 1984). A noteworthy topographic high is Casey Mountain (a Precambrian inlier) located on the eastern edge of the outlier. Glacial overburden over the outlier is thick and permits only limited exposure of the bedrock, except near the crest of the escarpment as it trends northwest from Dawson Point.

The western edge of the outlier is bounded by two northwesterly trending normal faults with a cumulative downthrow to the northeast of at least 240 m. The outlier's eastern edge is poorly defined, although it is also fault controlled. South of New Liskeard, the northwest trending faults are intersected by northeast trending faults (Russell, 1984).

Paleozoic rocks of the Lake Timiskaming outlier range in age from Middle Ordovician to Middle Silurian. The discussion which follows is summarized from Russell (1984). The oldest unit in the area is the Middle to Upper Ordovician Liskeard Group (Figure CO-0-2) which includes (in ascending order): the Guigues, Bucke, Farr, and Dawson Formations. These units consist of coarse-grained sandstones and conglomerates, interbedded blue-grey shales and nodular limestones, interbedded calcarenites and dolomitic limestones, and interbedded shales and calcarenites, respectively. Outcrops of the Liskeard Group occur within two smaller fault blocks south of the main outlier and west of Casey Mountain.


MIDDLE SILURIAN
Thornloe Fm.
Earlton Fm.
LOWER-MIDDLE SILURIAN
Wabi Group
Evantural Creek Fm.
Cabot Head Fm.
Manitoulin Fm.
MIDDLE-UPPER ORDOVICIAN
Liskeard Group
Dawson Point Fm.
Farr Fm.
Bucke Fm.
Guigues Fm.
PRECAMBRIAN
300
250
200
150
100
50
0
metres
CO-1
CO-2
CO-3
CO-4
CO-5
CO-1 MCNAMMARAS
CO-2 TOWNSHIP OF HARLEY
CO-3 HANBURY
CO-4 DYMOND CLAY PRODUCTS
CO-5 FARR

N.B. : Maximum thicknesses are assumed for this section

**Figure CO-0-2. STRATIGRAPHIC COLUMN SHOWING PRINCIPAL QUARRIES OF COBALT DISTRICT.**

Quarries have been developed in the Farr Formation, which is also the most extensively exposed unit of the group. The currently active Dymond Clay Products Ltd. Quarry (CO–4) (Grant and Owsiacki, 1987) exposes 4.6 m of this formation, as does the nearby abandoned Farr Quarry (CO–5).

The Lower to Middle Silurian Wabi Group disconformably overlies the Liskeard Group and consists of (in ascending order): the Manitoulin, Cabot Head, and Evanturel Creek Formations. They consist of mottled dolostones, red shales (both correlative to the Manitoulin Island and Bruce Peninsula sequences, respectively), and interbedded shales and dolostones. Only the Evanturel Creek Formation is exposed in the outlier along the creek of the same name.

The Wabi group is overlain by the Middle Silurian Earlton and Thornloe Formations, the former being a thin–bedded, very fine–crystalline limestone and dolostone with interbeds of bioclastic and oolitic limestones. The unit is well exposed at the southern tip of Dawson Point. Except for the abandoned quarry near the Earlton Airport (from which material was used for runway construction) there are no quarries in this formation.

The Thornloe Formation is a very thick–bedded dolostone which forms the crest of the spectacular cliff exposures along Dawson Point. This formation is also exposed in the intermittently–operated McNammaras (CO–1) and Township of Harley (CO–2) Quarries, and in the abandoned Hanbury Quarry (CO–3).

## CO–1 NORTARIO LIMESTONE LTD. — McNAMMARAS QUARRY

### LOCATION AND OWNERSHIP

This quarry, located 5 km north of Earlton in Lot 6, Concession 6, Armstrong Township, District of Timiskaming (Figure CO–1–1), has been operated intermittently by Nortario Limestone Ltd.

### GEOLOGY

The 3.3 m deep quarry exposes thin–bedded dolostones of the Thornloe Formation which contain some white chert nodules in addition to numerous, commonly silicified fossils. Material from this quarry has been used as a source of aggregate. Glacial overburden around the quarry is generally less than 1 m thick.

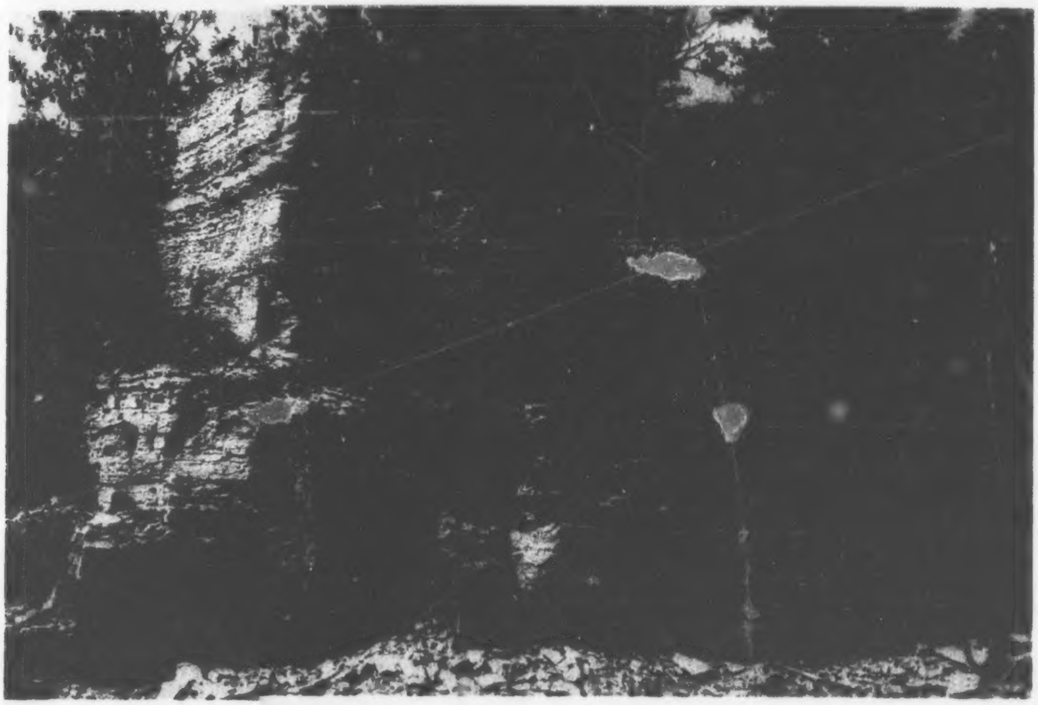


**Photo CO–1–1. SOUTH FACE AT MCNAMMARAS QUARRY.**

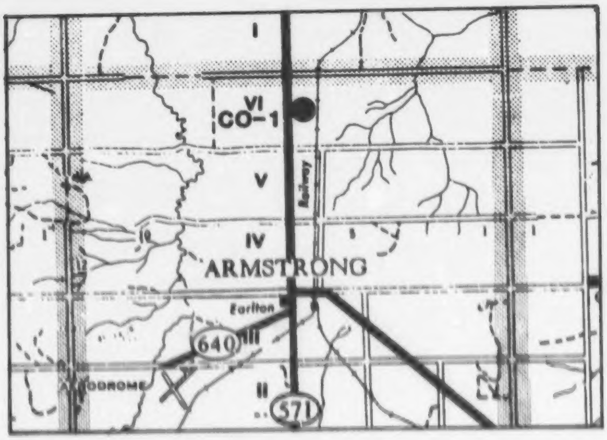

I
VI
CO-1
V
Railway
IV
ARMSTRONG
Earlton
640
III
II
571

Figure CO-1-1. LOCATION MAP FOR MCNAMMARAS QUARRY.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 1 Thornloe Formation* | *3.3m* |

Limestone: grey, weathers grey-brown, very fine crystalline; thin bedded; white chert nodules present (7 cm diameter), some reddish-brown stains on uppermost beds; shale and sandy limestone drapes are present; fossiliferous with crinoidal debris most abundant, and with rare colonial corals, stromatoporoids, bryozoa, trilobites and brachiopods; some beds are highly bioturbated.

| | |
|---|---|
| *Total thickness* | *3.3m* |

### REFERENCES

Bolton and Copeland, 1972, p.19
Grant and Owsiacki, 1987

### MAPS

Russell, 1984, OGS Map P.2700

## CO-2 TOWNSHIP OF HARLEY QUARRY

### LOCATION AND OWNERSHIP

This quarry, operated intermittently by the Township of Harley, is located 2 km southeast of the village of Thornloe, in Lot 7, Concession 6, Harley Township, District of Timiskaming (Figure CO-2-1).

### GEOLOGY

The quarry exposes 4.5 m of sandy dolostones from the Thornloe Formation. The material from this quarry is mainly used as fill because of the highly friable nature of the rock.

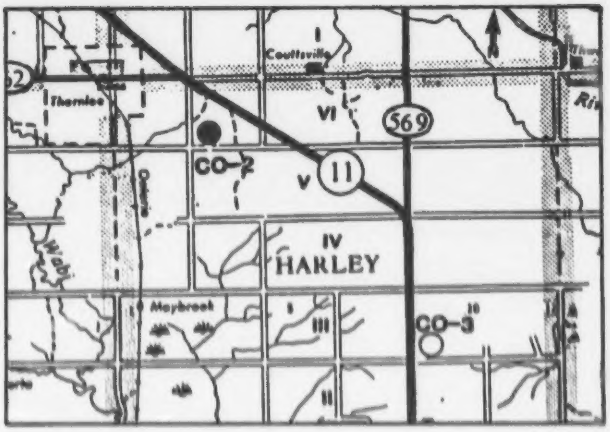

I
Couttsville
Thornloe
VI
569
CO-2
V
11
Wabi
Ontario
IV
HARLEY
Maybrook
III
CO-3
II

Figure CO-2-1. LOCATION MAP FOR TOWNSHIP OF HARLEY QUARRY.

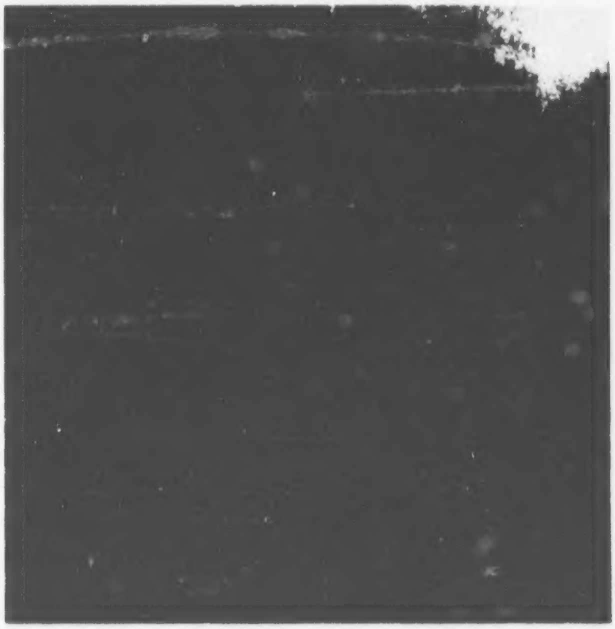


Photo CO-2-1. EAST FACE AT TOWNSHIP OF HARLEY QUARRY.

### Geological Section

*Thickness*

*UNIT 1 Thornloe Formation* *4.5m*

Sandy dolostone: light grey-brown, weathers medium brown, fine- to medium-grained quartz within fine- to medium-crystalline dolostone; medium to thick bedded; unit is very friable; lower 1.7 m forms a talus slope in most parts of the quarry; patches of white chert present in lower 1.7 m;fossiliferous with corals, stromatoporoids and pentamerid brachiopods abundant.

*Total thickness* *4.5m*

### REFERENCES

Bolton and Copeland, 1972, p.19
Grant and Owsiacki, 1987
Lovell and Frey, 1976

### MAPS

Russell, 1984, OGS Map P.2700
Lovell and Frey, 1974, OGS Map 2301

## CO-3 HANBURY QUARRY

### LOCATION AND OWNERSHIP

This abandoned quarry is located 2 km north of Hanbury, in Lot 9, Concession 3, Harley Township, District of Timiskaming (Figure CO-3-1).

### GEOLOGY

This quarry exposes 5.5 m of dolostones and interbedded sandy limestones of the Thornloe Formation. The quarry is partially overgrown and flooded.

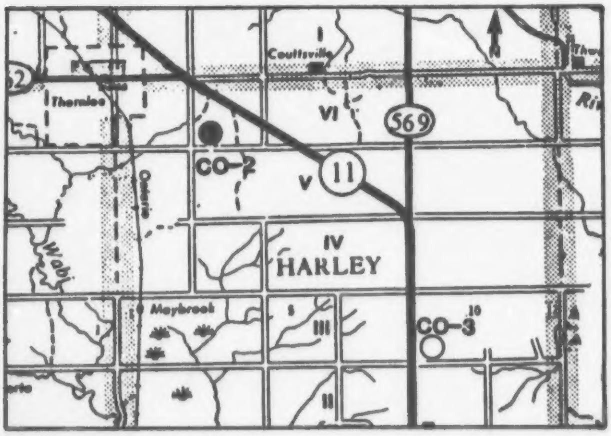


Figure CO-3-1. LOCATION MAP FOR HANBURY QUARRY.

### Geological Section

*Thickness*

*UNIT 1 Thornloe Formation* *5.5m*

Dolostone, with sandy limestones: grey, weathers grey-brown; fine crystalline; dolostone is very fine crystalline; limestone is microcrystalline and bioclastic; thin to thick bedded, with some beds laminated; abundant crinoids; low amplitude anticline is present on quarry floor.

*Total thickness* *5.5m*

### REFERENCES

Bolton and Copeland, 1972, p.19
Grant and Owsiacki, 1987

### MAPS

Lovell and Frey, 1974, OGS Map 2301
Russell, 1984, OGS Map P. 2700

## CO-4 DYMOND CLAY PRODUCTS LTD. — BUCKE QUARRY

### LOCATION AND OWNERSHIP

Dymond Clay Products Ltd. own and operate a limestone quarry approximately 2.5 km northwest of Haileybury, in Lot 9, Concession 4, Bucke Township, District of Timiskaming (Figure CO-4-1). The property was first developed in 1980, primarily for its agricultural lime potential, by the parent company Jacksic Brothers Sand & Gravel of New Liskeard. Since 1980 Dymond Clay Products Ltd. has expanded from producing small amounts of agricultural lime to supplying metallurgical stone for flux. The quarry produced about 130,000 tonnes in 1986 with over 90% of production used in the pelletizing operations of local iron mines (Owsiacki, 1987).

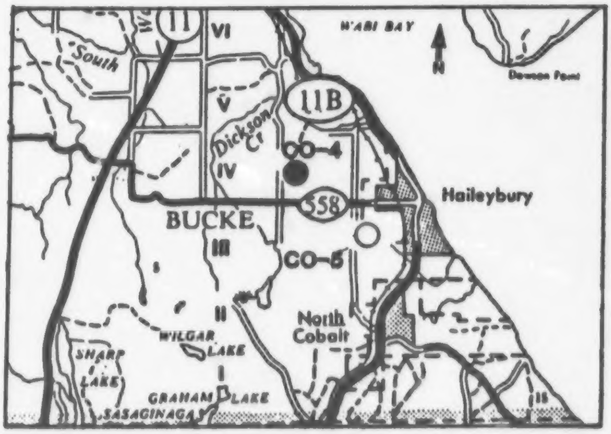


Figure CO-4-1. LOCATION MAP FOR BUCKE QUARRY.

**Photo CO-4-1. PORTABLE CRUSHING FACILITIES AT BUCKE QUARRY (LOOKING NORTH).**

### GEOLOGY

The 4.6 m deep quarry exposes limestones and interbedded dolostones of the Farr Formation. The high purity of the carbonates makes this stone suitable for use as a metallurgical flux and as agricultural lime.

### Geological Section

| | | Thickness |
|---|---|---|
| *UNIT 1* | *Farr Formation* | *4.6m* |

Limestone, with some interbedded dolostones: medium to dark grey, weathers light brown; medium- to coarse-crystalline limestones and very fine- to fine-crystalline dolostone; medium to thick bedded, upper beds thinner, sharp but irregular contacts; in upper half of unit thin shale partings occur; weathered surfaces show distinct mottling and pitting; sparsely fossiliferous although large corals are present.

*Total thickness* *4.6m*

### QUARRY OPERATION

As of July 1986 the quarry had dimensions of about 50 m x 50 m, opened on a single lift of 6 m, with potential for deepening to 12 m. Overburden is about 2 m in thickness, consisting of loose limestone boulders and clay, and is stockpiled and later screened to produce riprap and armour stone. Drilling and blasting is contracted and a 2.4 m x 2.4 m drill pattern is used with 7.6 cm diameter holes.

### PROCESSING

A Cat 988 loader is used to transport shot rock from the blast face to the primary crusher. At the time of the visit the primary crusher (Cedarapids jaw) was set up on the quarry floor. Crushed stone was conveyed to a Pioneer secondary crusher on the rim of the quarry, producing -1 in. material that was stockpiled.

Stone from the stockpile was either trucked to customers as a metallurgical stone product or transported approximately 100 m by front-end loader to a Stedman Cage Crusher for tertiary crushing. Material leaving the cage crusher was carried by a 9 in. paddle conveyor to a stacker for storage in a 6,000 tonne shed.

### PRODUCTS

Armour Stone
Riprap
-1 in. Metallurgical Stone
Agricultural Lime

### REFERENCES

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### MAPS

Russell, 1984, OGS Map P.2700

## CO-5 FARR QUARRY

### LOCATION AND OWNERSHIP

This abandoned quarry is located 1.5 km west of Haileybury, in Lot 5, Concession 3, Bucke Township, District of Timiskaming (Figure CO-5-1).

### GEOLOGY

The 6 m deep quarry exposes limestone from the Farr Formation. The quarry was originally used as a source of building stone which resulted in five shallow lifts, each essentially one bed thick. Glacial overburden around the quarry is generally less than 0.5 m thick.

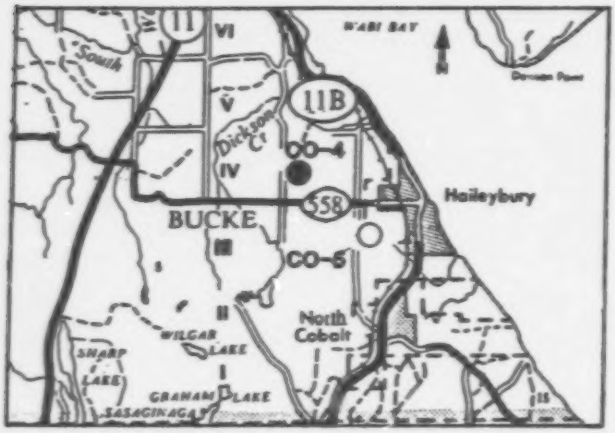
South
11
VI
WABI BAY
Dawson Point
V
11B
Dickson Ck
IV
CO-4
Haileybury
558
BUCKE
III
CO-5
II
North Cobalt
WILGAR LAKE
SHARP LAKE
I
GRAHAM LAKE
SASAGINAGA
11

Figure CO-5-1. LOCATION MAP FOR FARR QUARRY.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 1 Farr Formation* | *6.0m* |

**Limestone: medium grey, weathers blue-grey; fine to medium crystalline; becomes coarser crystalline upwards; thick bedded; some beds with minor amounts of coarse-grained sand; sharp contacts with rare thin shale partings; calcite crystals line vugs; abundant fossils include stromatoporoids and brachiopods, with rare corals, gastropods, and the algae *Receptaculites*.**

| | |
|---|---|
| *Total thickness* | *6.0m* |

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### MAPS

Russell, 1984, OGS Map P.2700

# Moosonee District

## INTRODUCTION

There is only one quarry located in Moosonee District. The quarry is operated by M.J. Labelle Co. Ltd. which has several aggregate operations in northeastern Ontario.

## PALEOZOIC GEOLOGY

The Moose River Basin occupies the James Bay Lowland physiographic area including Moosonee District and contains Paleozoic and Mesozoic age strata totalling approximately 760 m in thickness (Figure MO–0–1). This sequence includes Ordovician, Silurian, Devonian, Middle Jurassic and Lower Cretaceous age rocks.

The James Bay Lowland area is covered with poorly-drained muskeg resulting in sparse bedrock exposures along river banks and severely limiting accessibility and transportation for limestone quarrying. The main modes of surface transportation through the James Bay Lowland in summer are by canoe or small boat on the rivers, or by the Ontario Northland Railway.

The main carbonate units of the Moose River are those of Middle Devonian age. The Kwataboahegan Formation (MO–1) is the only one of these which has thus far been exploited.

## MO–1 M. J. LABELLE CO. LTD. – MOOSONEE QUARRY

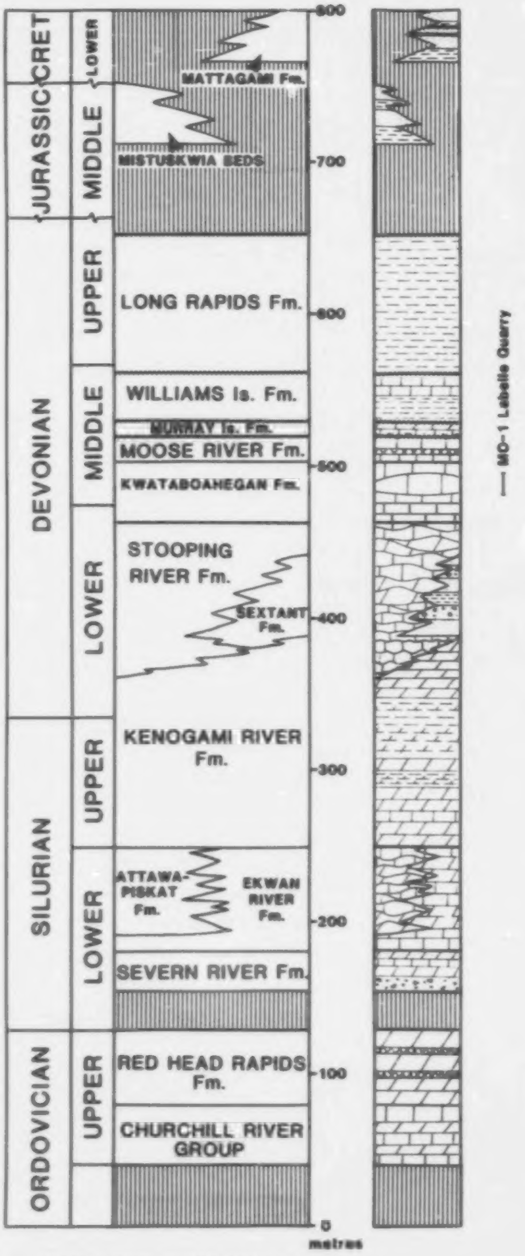
### LOCATION AND OWNERSHIP

The Moosonee Quarry is located 8 kms south of Moosonee, in Lot 7, Concession 8, Horden Township, Cochrane District and is adjacent to Maidmans Creek, next to the Moose River (Figure MO–1–1). The quarry was opened in 1970 by the operator M. J. Labelle Co. Ltd.

Deposits of sand and gravel in the Moosonee area are limited, therefore aggregate material must be supplied from limestone sources. Crushed stone products from the quarry are used in road and airport maintenance in Moosonee and Moose Factory. The quarry is usually put into operation every winter as the product stockpiles become exhausted. Approximately 50,000 tonnes are extracted and crushed to replenish the stockpiles. All excavation/crushing equipment is shipped by rail from Cochrane to Moosonee.

### GEOLOGY

The Moosonee Quarry exposes approximately 6 m of Middle Devonian Kwataboahegan Formation limestone in three lifts. The Kwataboahegan Formation, at its type location at Coral Rapids (on the Abitibi River), is typi-



JURASSIC
CRET
LOWER
MIDDLE
MATTAGAMI Fm.
MISTUSKWIA BEDS
DEVONIAN
UPPER
LONG RAPIDS Fm.
MIDDLE
WILLIAMS ls. Fm.
MURRAY ls. Fm.
MOOSE RIVER Fm.
KWATABOAHEGAN Fm.
LOWER
STOOPING RIVER Fm.
SEXTANT Fm.
SILURIAN
UPPER
KENOGAMI RIVER Fm.
LOWER
ATTAWAPISKAT Fm.
EKWAN RIVER Fm.
SEVERN RIVER Fm.
ORDOVICIAN
UPPER
RED HEAD RAPIDS Fm.
CHURCHILL RIVER GROUP
800
700
600
500
400
300
200
100
0
metres
MO-1 Labelle Quarry

Modified after Norris(1986) p.23

Figure MO-0-1. STRATIGRAPHIC COLUMN FOR THE MOOSE RIVER BASIN AND MOOSONEE QUARRY.

cally a light to dark brown, calcarenaceous, bituminous, thick– to massive–bedded, extremely fossiliferous limestone. It weathers light grey to grey, and occasional recessive dolomitic beds also occur. Some beds have a microgranular to microsucrosic texture and are highly porous. At other localities it is thin–bedded, darker, less fossiliferous, and very bituminous. It is the most fossiliferous unit in the Moose River Basin and includes corals, stromatoporoids, bryozoans, tentaculitids, crinoids, pelecypods, gastropods, trilobites, ostracods, and conodonts. This unit has tentatively been correlated with the Onondaga Formation in southern Ontario. The silty overburden is up to 2.7 m thick around the quarry.

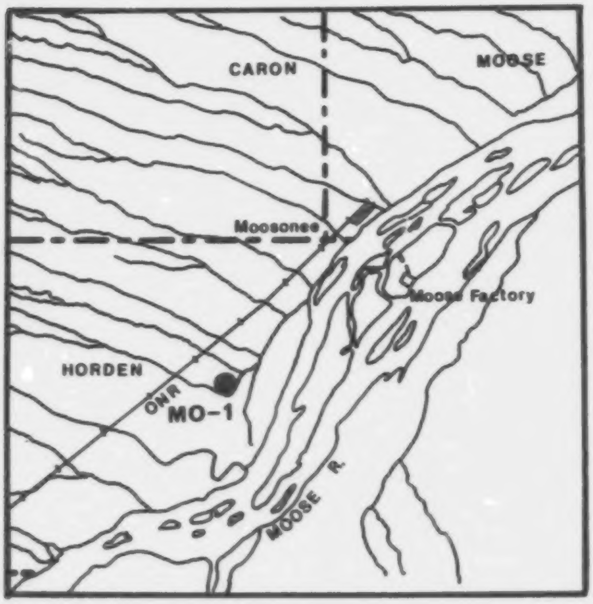


Figure MO-1-1. LOCATION MAP FOR MOOSONEE QUARRY.

## QUARRY OPERATION

The quarry is excavated on three lifts of approximately 4 m over an area of 2 ha. The Moosonee region possesses a high water table hence all overburden stripping, drilling/blasting and primary crushing are performed during the winter season. A 10 in. diesel pump is used to dewater the quarry. All blast holes are loaded with water-gel explosives (column charge) and stick powder (toe charge), initated by electric caps.

## PROCESSING

A Pioneer 30 in. x 42 in. jaw is used for primary crushing, and a Cedarapids 877 Master Commander (32 in. x 41 in. roll and 12 in. x 42 in. jaw) as a secondary crusher. The Commander crusher is equipped with a 5 ft. x 16 ft. double–deck screen and ball tray (to remove soil).

## PRODUCTS

4 in. Crusher Run (for fill base)
Granular "A"
3/4 in. Concrete Stone (washed)
Approved Asphalt Stone
5/8 in. (washed)

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# Volume

# 3

# Limestone Industries of Ontario

## Volume III — Limestone Industries and Resources of Central and Southwestern Ontario

Ontario

Ministry of
Natural
Resources

Vincent G. Kerrio
Minister

Ministry of
Northern Development
and Mines

Sean Conway
Minister

# LIMESTONE INDUSTRIES OF ONTARIO

## Volume I — Geology, Properties and Economics

- Paleozoic Geology of Ontario
- Precambrian Carbonate Resources
- Properties, Specifications and Uses
- Production, Economics and Markets

## Volume II — Limestone Industries and Resources of Eastern and Northern Ontario

- Eastern Ontario
  - *Cornwall District*
  - *Carleton Place District*
  - *Brockville District*
  - *Napanee District*
  - *Tweed District*
  - *Pembroke District*
- Northern Ontario
  - *Espanola District*
  - *Blind River District*
  - *Cobalt District*
  - *Moosonee District*

## Volume III — Limestone Industries and Resources of Central and Southwestern Ontario

- Central Ontario
  - *Lindsay and Minden Districts*
  - *Huronia District*
  - *Maple District*
  - *Cambridge District*
  - *Niagara District*
- Southwestern Ontario
  - *Owen Sound District*
  - *Simcoe District*
  - *Aylmer District*
  - *Wingham District*
  - *Chatham District*

# Limestone Industries of Ontario

## Volume III — Limestone Industries and Resources of Central and Southwestern Ontario

Prepared for the Aggregate Resources Section,
Land Management Branch, Ontario Ministry of Natural Resources

by
Derry Michener Booth and Wahl
and
Staff of the Engineering and Terrain Geology Section, Ontario Geological Survey,
Ministry of Northern Development and Mines

1989

Ontario

Ministry of
Natural
Resources

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*Cover photo of St. Marys Cement plant is courtesy of St. Marys Cement.*

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A large study such as this is completed only through the efforts of many people. The geological/mining engineering firm, Derry Michener Booth and Wahl, was the lead consultant and was responsible for the plant inventory and descriptions. Staff who prepared the material included David Wahl, Martin Taylor, Wes Roberts and Charles Pitcher, with the assistance of W.G. Wahl, Wahlex Ltd., G. Robert Guillet, Consultant, and Jack Kriens, IMD Laboratories. Don Hains of Hains Technology Associates was responsible for the material on commodities and economics of the limestone industries. Mr. Hains and Mr. W.G. Wahl prepared the plant descriptions for cement, lime and fillers operations.

Staff of the Engineering and Terrain Geology Section, Ontario Geological Survey of the Ministry of Northern Development and Mines prepared the geological description of each site as well as the regional descriptions of the geology of limestone and related carbonate rocks in Volume I. This work was supervised by Dr. Owen White, Chief, Engineering and Terrain Geology Section, and Mike Johnson, Acting Supervisor, Paleozoic/Mesozoic Geology Sub-Section. Staff involved in preparing the site descriptions included Dr. Max Vos, Rainer Wolf, Ruth Bezys, Derek Armstrong, Julie Stevenson–Demeester, Val Mazur, and Chris Fouts. Dr. Peter Telford of the Mineral Development and Lands Branch, Ministry of Northern Development and Mines assisted in the interpretation of geological data and the review of the report.

The project was initiated by the Aggregate Resources Section, Ministry of Natural Resources, under the direction of Dale Scott. Geoff Bell was the project coordinator and report editor.

# Preface

Products from the limestone industries find their way into many of the items that are essential to our modern way of life. In one way or another, the output of the various members of the limestone industries is used in constructing or manufacturing items as diverse as office towers, homes, transportation networks, steel, glass, paper, or rubber products.

This report examines Ontario's limestone industries from two perspectives: the geological resource, including limestone, dolostone, marble and carbonatites; and secondly, the various industries which rely on these resources to manufacture products which are vital to Ontario's economy. These products include construction aggregate, cement, lime, fillers and extenders, building stone and pulverized stone.

In order to undertake a study on such a large and important economic sector, a steering committee was struck to formulate the terms of reference for the study and guide the research and field work through to the report stage. Members of the steering committee were:

- Dale Scott, Chairman, Ministry of Natural Resources
- Norris Walker, Aggregate Producers' Association of Ontario
- Vic Perry, Canadian Portland Cement Association
- Don Stonehouse, Energy Mines and Resources Canada
- Dr. Owen White, Ministry of Northern Development and Mines
- Dr. Peter Telford, Ministry of Northern Development and Mines
- Dr. Max Vos, Ministry of Northern Development and Mines
- Mike Johnson, Ministry of Northern Development and Mines
- Zoltan Katona, Ministry of Transportation
- Chris Rogers, Ministry of Transportation
- Geoff Bell, Executive Secretary, Ministry of Natural Resources

The study brings together the most up to date geological information pertaining to carbonate rocks and describes the current operations of the members of the limestone industry. In addition, information on the economics of the various commodities is presented in order to give a more complete picture of this resource activity. Field work and data compilation were performed in 1986 and 1987. The authors have attempted to incorporate changes in plant design and ownership up until summer 1988.

The geological and plant site descriptions are organized based on the Ministry of Natural Resources administrative districts. This approach was taken to accommodate the multi–commodity nature of the industry, as well as to facilitate review of the material. This format also allows district updates of activity to be produced easily at a future date.

Metric units are used in the geological descriptions throughout the report, and in parts of the plant and operations descriptions. Since plant equipment is normally sized in Imperial units, these measurements have not been converted to metric units for ease of presentation.

# Contents

**Part 1 Central Ontario** 1
Lindsay and Minden Districts 2
  Introduction 2
  Regional Geology 2
  Limestone Industries 5
  L-1 St. Marys Cement Company — Bowmanville Quarry and Plant 5
  L-2 Miller Paving Limited — Dalrymple Quarry 8
  L-3 Gormley Aggregates Limited — Carden Quarry 9
  L-4 Cedarhurst Crushing & Quarries Ltd. — Coboconk East Quarry 12
  L-5 Britnell Quarry 13
  L-6 Nelson Windover — Nichols (Flynns Turn) Quarry 14
  L-7 Ormell Sand and Gravel Limited — Harvey Quarry 15
  L-8 Nelson Windover — Home (Buckhorn) Quarry 16
  L-9 Eldred W. Payne — Warsaw Quarry 17
  L-10 Harnden and King Construction (Ontario) Limited — [illegible]lock Quarry 18
  L-11 Bolenders Limited — Eagle Lake Marble Quarry 18
Huronia District 20
  Introduction 20
  Regional Geology 20
  Limestone Industries 23
  H-1 McKean Quarries Limited — Duntroon Quarry 23
  H-2 Duntroon Quarry 24
  H-3 Allan G. Cook Ltd. — Coldwater (Waubaushene) Quarry 25
  H-4 Ministry Of Transportation — Medonte (Coldwater) Quarry 27
  H-5 Nelson Aggregate Company — Uhthoff Quarry 28
  H-6 Fowler Construction Co. Ltd. — Woods (Longford) Quarry 33
  H-7 Rama Township Quarry 34
  H-8 Mara Limestone Aggregates Ltd. — Gamebridge Quarry 35
  H-9 Standard Aggregates Ltd. — Brechin Quarry 36
  H-10 C.S. Speiran — Speiran Quarry 39
Maple District 41
  Introduction 41
  Regional Geology 42
  Limestone Industries 42
  MA-1 St. Lawrence Cement Company Inc. — Mississauga (Clarkson) Plant 42
Cambridge District 44
  Introduction 44
  Regional Geology 44
  Limestone Industries 47
  CB-1 Guelph Correctional Centre Quarry 47
  CB-2 Guelph Dolime Ltd. — Quarry and Lime Plant 49
  CB-3 United Aggregates Ltd. — Acton Quarry 51
  CB-4 Dufferin Aggregates — Milton (Dufferin) Quarry 55
  CB-5 Halton Crushed Stone Ltd. — Halton Quarry 59
  CB-6 Milton Limestone — Milton Quarry 61
  CB-7 Nelson Aggregate Co. — Nelson Quarry 64
  CB-8 Old Nelson Quarry 67
  CB-9 Flamboro Quarries Ltd. 69
  CB-10 Clappison's Corners Quarry 70
  CB-11 Steetley Lime & Aggregates Division — Dundas Quarry 71

CB–12 Taro Aggregates Inc. — Stoney Creek Quarries ........ 74
CB–13 Waterford Sand and Gravel Ltd. — Vinemount Quarry ... 77
CB–14 Arriscraft Corporation ........ 79

Niagara District ........ 81
NI–1 Nelson Aggregate Co. — Lincoln Quarry ........ 84
NI–2 Vineland Quarries and Crushed Stone Ltd. — Vineland Quarry ........ 87
NI–3 Walker Brothers Quarries Ltd. — Thorold Quarry ........ 89
NI–4 Steetley Industries Ltd. — Queenston Quarry ........ 92
NI–5 Standard Aggregates Incorporated — Hagersville Quarry ... 94
NI–6 Nelson Aggregate Co. — West Oneida Quarry ........ 98
NI–7 Nelson Aggregate Co. — East Oneida Quarry ........ 98
NI–8 Cayuga Materials and Construction Co. — Cayuga Quarry .. 99
NI–9 Sweets Corners Quarries ........ 102
NI–10 Dunnville Rock Products Ltd. Quarry ........ 102
NI–11 Hard Rock Paving Co. Ltd. — R.E. Law Quarry ........ 105
NI–12 Port Colborne Quarries Ltd. — Port Colborne Quarry .... 108
NI–13 Bertie Bay Quarry ........ 112
NI–14 Ridgemount Quarries Ltd. — Pit 1 ........ 112
NI–15 Ridgemount Quarries Ltd. — Pits 2 And 3 ........ 114
NI–16 Clinton Quarry Ltd. ........ 116

**Part 2 Southwestern Ontario ........ 118**

Owen Sound District ........ 119
O–1 Arriscraft Corporation — Adair Marble Quarry ........ 122
O–2 Moor Developments Inc. Quarry ........ 124
O–3 Amsen Quarry Ltd. — Ross Quarry ........ 125
O–4 J.S. Cook — Cook Quarry ........ 127
O–5 Owen Sound Ledgerock — Wiarton Quarry ........ 128
O–6 R.G. Ebel — Ebel Quarries ........ 130
O–7 C.E. McCartney Quarry ........ 131
O–8 Owen Sound Ledgerock Ltd. — Owen Sound (Cruickshank) Quarry ........ 132
O–9 E.C. King Contracting — Tolhurst Quarry ........ 133
O–10 E.C. King Contracting — Sydenham Quarry ........ 134
Harold Sutherland Construction Ltd. Quarry ........ 135

Simcoe District ........ 136
S–1 C. Mattice — Pierce Quarry ........ 138
S–2 Norfolk Quarries Company — Norfolk (Port Dover) Quarry . 138

Aylmer District ........ 141
A–1 Lafarge Canada Inc. — Woodstock (Zorra) Quarry and Plant ........ 143
A–2 BeachviLime Ltd. Quarry and East Plant ........ 145
A–3 BeachviLime Ltd. Quarry and West Plant ........ 149
A–4 Stelco Steel Quarry ........ 151
A–5 Federal White Cement Ltd. — Woodstock Plant ........ 154

Wingham District ........ 155
W–1 St. Marys Cement Company — Quarry and Plant ........ 156

Chatham District ........ 161
CH–1 General Chemical Canada Ltd. — MacGregor Quarry ..... 163
CH–2 General Chemical (Allied Chemical) Quarry (Abandoned) . 166
CH–3 Amherst Quarries (1969) Ltd. — Amherstburg Quarry .... 167
CH–4 670026 Ontario Limited — Pelee Island Quarry ........ 170

**References Cited ........ 172**

# Part 1
# Central Ontario

# Lindsay and Minden Districts

## INTRODUCTION

For the purpose of this study, the limestone quarries occurring in Lindsay and Minden Districts will be discussed together.

Lindsay District is situated in the Central Region of southern Ontario bounded by Lake Ontario on the south, Maple District on the west, Minden and Bancroft Districts on the north and Tweed and Napanee Districts on the east.

Minden District is situated in the Algonquin Region of southern Ontario and adjoins Lindsay District to the south. It is bounded on the west by the Huronia District, Bracebridge and Algonquin Districts on the north and by Bancroft District on the east.

The combined Lindsay and Minden Districts include all or portions of Victoria, Peterborough, Haliburton and Northumberland Counties, and the Regional Municipality of Durham. A total of 45 quarry properties have been documented in the combined districts including 22 in Minden and 23 in Lindsay (Appendix IV, Volume I). Eleven sites were examined in detail during the study and include:

| | |
|---|---|
| *L-1* | *St. Marys Cement Company - Bowmanville Quarry and Plant (active)* |
| *L-2* | *Miller Paving Limited - Dalrymple Quarry (active)* |
| *L-3* | *Gormley Aggregates Limited - Carden Quarry (active)* |
| *L-4* | *Cedarhurst Crushing & Quarries Ltd. - Coboconk East Quarry (active)* |
| *L-5* | *Britnell Quarry (abandoned)* |
| *L-6* | *Nelson Windover - Nichols (Flynns Turn) Quarry (intermittent)* |
| *L-7* | *Ormell Sand and Gravel Limited - Harvey Quarry (active)* |
| *L-8* | *Nelson Windover - Home (Buckhorn) Quarry (intermittent)* |
| *L-9* | *Eldred W. Payne - Warsaw Quarry (intermittent)* |
| *L-10* | *Harnden and King Construction (Ontario) Limited - Havelock Quarry (intermittent)* |
| *L-11* | *Bolenders Limited - Eagle Lake Marble Quarry (active)* |

## REGIONAL GEOLOGY

The northeastern part of Minden District is underlain by Precambrian rocks of Grenville age, predominantly clastic metasediments, metavolcanics and associated calcitic and dolomitic marbles. A single active quarry, the Eagle Lake Marble Quarry (L-11) exposes Grenville marbles.

Lindsay District and the adjacent southern Minden District extend southwards from the Kawartha Lakes area to Lake Ontario. Between Whitby and Cobourg the study area encompasses parts of Victoria, Peterborough, and Northumberland Counties, and Durham Region (Figure L-0-1). The main geomorphic features in the districts are the Oak Ridges Moraine, the Peterborough Drumlin Field, which together occupy much of the area. Other features are the Kawartha Lakes in the north, Rice Lake in the east, and the Lake Ontario shoreline to the south.

Most of the area is underlain by rocks of Paleozoic age, with some Precambrian rocks present in the north. The Paleozoic-Precambrian contact approximately follows the northern boundary of the Lindsay District with some inliers of Precambrian and outliers of Paleozoic rocks occurring on either side of this contact. The contact is usually delineated by a northward facing limestone scarp on or near the southern shores of the Kawartha Lakes.

The Paleozoic rocks occurring in the Lindsay District range in age from Middle to Upper Ordovician and include (in ascending order): Shadow Lake, Gull River, Bobcaygeon, Verulam, and Lindsay Formations (see Figure L-0-2).

The Shadow Lake Formation usually consists of a basal conglomerate overlain by arkosic sandstones and shales. It varies in thickness from zero, where it is absent over Precambrian topographic highs, up to 10 m thick where it infills lows in the Precambrian surface. There are only small scattered exposures of the Shadow Lake Formation in the Lindsay and Minden Districts, and there are no quarries which expose this formation.

Overlying the Shadow Lake Formation is the Gull River Formation, which outcrops in southern Minden and northern Lindsay Districts as a narrow band along the southern shores of the Kawartha Lakes, and forms the main rock unit in the Paleozoic outliers. There are numerous quarries utilizing the Gull River in these districts, including several small building stone operations.

The Gull River Formation is subdivided in two members, based on the definition of Williams (in prep.) and the exposure in the Marmora Pit (TW-1), which is in the adjacent Tweed District to the east. This differs from the three-fold subdivision proposed by Liberty (1969), which was used for the quarry descriptions in the Huronia District to the west. The Gull River Formation (as used in this report) varies in thickness from 10 to 30 m with the lower member varying the most.

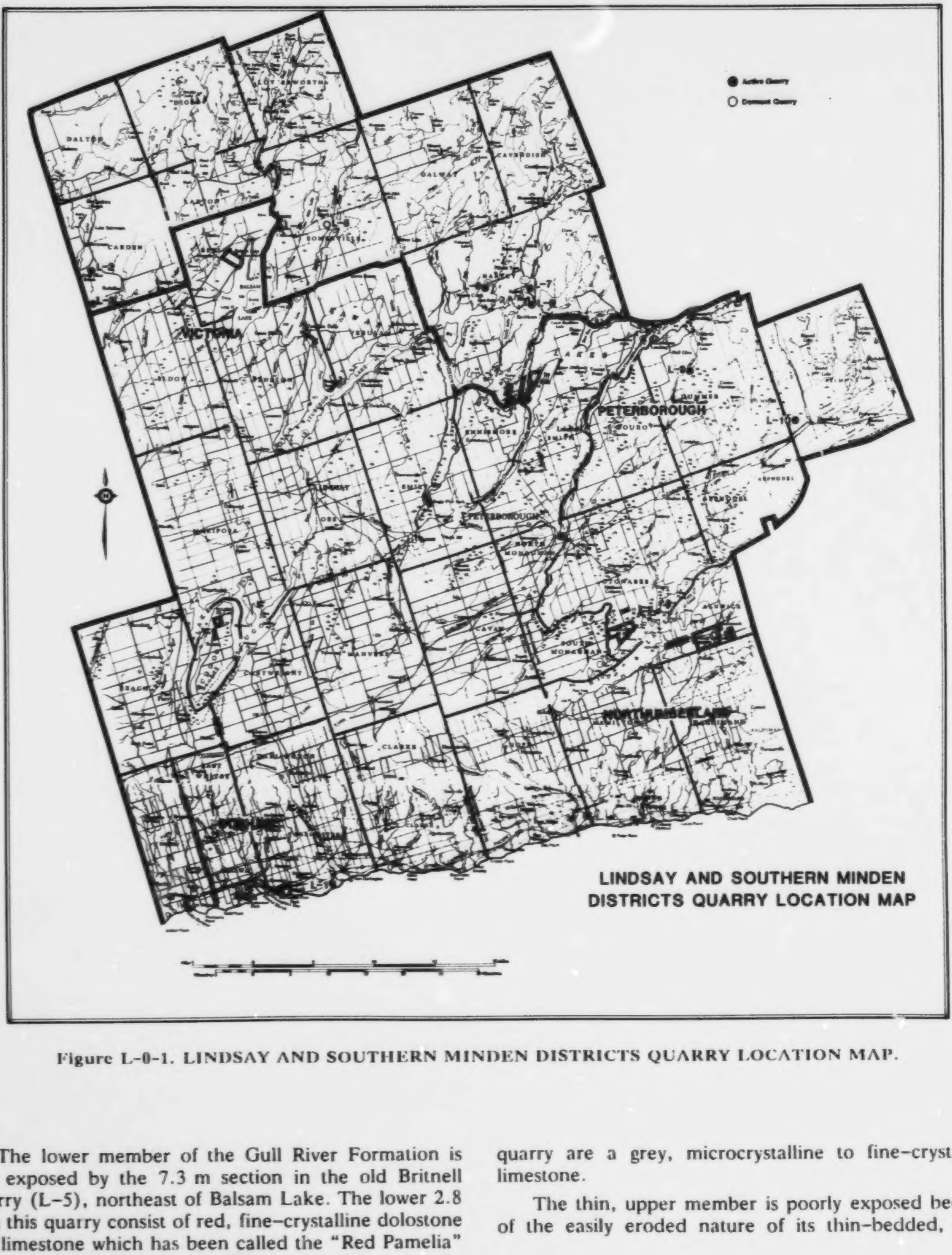
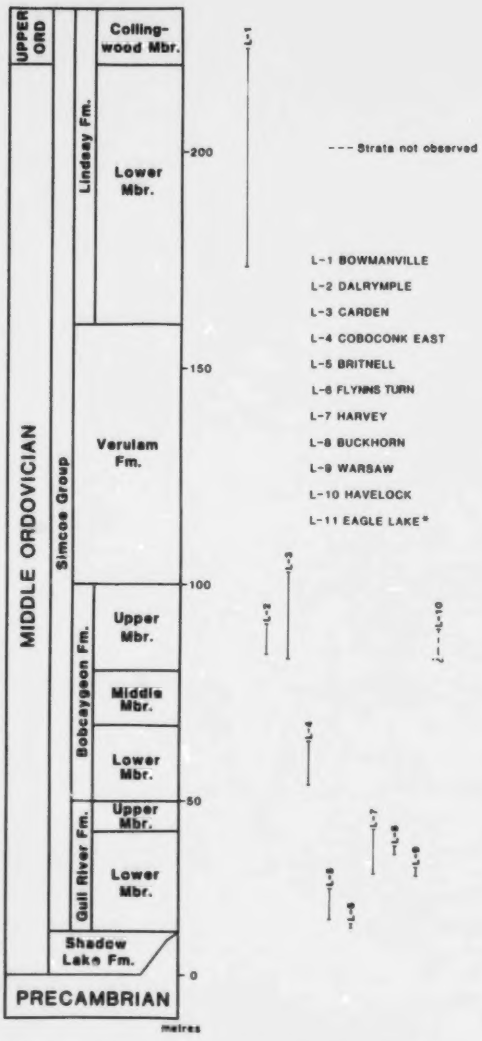

Active Quarry
Dormant Quarry
DALTON
DIGBY
CAVENDISH
GALWAY
LAXTON
CARDEN
SOMERVILLE
VICTORIA
ELDON
FENELON
HARVEY
PETERBOROUGH
ENNISMORE
SMITH
DOURO
DUMMER
L-10
ASPHODEL
EMILY
OPS
MARIPOSA
NORTH MONAGHAN
OTONABEE
CAVAN
MANVERS
CARTWRIGHT
SOUTH MONAGHAN
NORTHUMBERLAND
CLARKE
LINDSAY AND SOUTHERN MINDEN
DISTRICTS QUARRY LOCATION MAP

Figure L-0-1. LINDSAY AND SOUTHERN MINDEN DISTRICTS QUARRY LOCATION MAP.

The lower member of the Gull River Formation is best exposed by the 7.3 m section in the old Britnell Quarry (L-5), northeast of Balsam Lake. The lower 2.8 m in this quarry consist of red, fine-crystalline dolostone and limestone which has been called the "Red Pamelia" by the building stone trade. The upper 4.5 m in the quarry are a grey, microcrystalline to fine-crystalline limestone.

The thin, upper member is poorly exposed because of the easily eroded nature of its thin-bedded, shaly


UPPER ORD
MIDDLE ORDOVICIAN
Simcoe Group
Lindsay Fm.
Collingwood Mbr.
Lower Mbr.
Verulam Fm.
Bobcaygeon Fm.
Upper Mbr.
Middle Mbr.
Lower Mbr.
Gull River Fm.
Upper Mbr.
Lower Mbr.
Shadow Lake Fm.
PRECAMBRIAN
200
150
100
50
0
metres
--- Strata not observed
L-1 BOWMANVILLE
L-2 DALRYMPLE
L-3 CARDEN
L-4 COBOCONK EAST
L-5 BRITNELL
L-6 FLYNNS TURN
L-7 HARVEY
L-8 BUCKHORN
L-9 WARSAW
L-10 HAVELOCK
L-11 EAGLE LAKE*
L-1
L-2
L-3
L-4
L-5
L-6
L-7
L-8
L-9
L-10

N.B. : Maximum thicknesses are assumed for this section

* Extracting from Precambrian

Figure L-0-2. STRATIGRAPHIC COLUMN SHOWING PRINCIPAL QUARRIES OF LINDSAY AND MINDEN DISTRICTS.

limestone. No quarries in these districts expose the upper member.

The Bobcaygeon Formation is subdivided into three members, based on their shale content (Williams, in prep.). The lower and upper members generally have minor amounts of interbedded shale whereas the middle member has more significant amounts. The limestones of the lower member consist of thick to massive beds of microcrystalline limestone and medium to thick beds of medium– to coarse–grained calcarenites. The limestones of the middle and upper members are thin– to medium–bedded, fine– to medium–crystalline limestone and medium–grained calcarenitic limestone. The formation may be up to 50 m thick in the Lindsay District.

The lower member of the Bobcaygeon Formation is exposed in the Coboconk East (L–4) Quarry. Unpublished drillhole logs from near the Coboconk East Quarry (L–4) (D.A. Williams, personal communication, 1986) indicate that thin–bedded shaly limestone, interbedded dolostones and limestones, and shales and conglomerates (the upper and lower members, Gull River Formation, and Shadow Lake Formation, respectively, in descending order) underlie the thick– bedded limestone exposed in the quarry.

The middle member is not exposed in any quarries in Lindsay District or the southern part of Minden District.

In the Carden Quarry (L–3), 16.8 m of the upper member are exposed and overlain by 3.2 m of the Verulam Formation. The medium–grey, thin–to medium–bedded, fine– to medium–crystalline limestones to coarse–grained calcarenites contain abundant bryozoans and some brachiopods and rugose corals. Shale partings are generally thin throughout the member except for increasingly thicker shale partings below the Verulam Formation contact. The upper member is also well exposed in a 6.7 m section in the Dalrymple Quarry (L–2).

The contact between the Bobcaygeon and (overlying) Verulam Formations can be seen in the Carden Quarry (L–3) where 3.2 m of the Verulam Formation cap the quarry.

The Verulam Formation consists of thin–bedded, interbedded limestone, shaly limestone, and shale. The limestones vary from evenly textured, fine–crystalline to medium– to coarse–crystalline bioclastic beds. Parts of the formation weather to a distinctive blue–grey, although it usually weathers medium to light grey. The formation is up to 60 m thick in the Lindsay District.

Although the Verulam Formation underlies much of the Lindsay District, exposures of this formation are not abundant. The Carden Quarry (L–3) is the only operating quarry in which the rock is seen. Several abandoned quarries in the district expose the Verulam Formation, including the Lakehurst, Peterborough North and Lakefield Quarries (*see* Appendix IV, Volume I).

Overlying the Verulam Formation is the Lindsay Formation which underlies the southern portion of Lindsay District. The Lindsay Formation is subdivided into two members (Russell and Telford, 1983) in which the nodular limestone of the lower member, as used in this report, corresponds to the Lindsay Formation as defined by Liberty (1969). The black shales of the upper, Collingwood Member had been assigned to the lower member of the Whitby Formation by Liberty (1969). Recent subsurface studies of this part of the section

(Johnson et al., 1983) suggest that the black shales of the Collingwood Member can be incorporated into the Lindsay Formation as the upper member because of the highly calcareous nature of the shales and the apparently conformable contact between the two units (Russell and Telford, 1983).

The lower member of the Lindsay Formation has a total thickness of approximately 60 m. It consists mainly of grey to brown, fine-crystalline, medium-to thick-bedded, nodular limestone. The upper member of the Lindsay Formation is the Collingwood Member which underlies only the very southern portion and is the youngest unit in the Lindsay District. It is a calcareous, petroliferous black shale with a rich invertebrate fossil fauna, characterized by abundant trilobites which are concentrated into thin bioclastic beds. The contact between the lower and Collingwood members of the Lindsay Formation also marks the contact between the Middle and Upper Ordovician in Central Ontario.

The Bowmanville Quarry (L–1) is the only active quarry in Ontario which exposes the contact between the Middle Ordovician lower member and the Upper Ordovician Collingwood Member of the Lindsay Formation. In this very large quarry, the 4.3 m of black shale of the Collingwood Member overlie 42.7 m of nodular limestones of the lower member, Lindsay Formation.

## LIMESTONE INDUSTRIES

The limestone industries of the Lindsay and Minden Districts include production of cement, aggregate, building stone and marble chips.

Stone production in 1986 for the area amounted to approximately 2,450,000 tonnes. Nearly half of the stone was produced in the County of Victoria. The majority was produced by Gormley Aggregates Limited –Carden Quarry (L–3) and was used in the construction industry as road and concrete aggregate.

The Regional Municipality of Durham accounted for much of the remaining production. All of the stone was produced by St. Marys Cement Company from their Bowmanville Quarry and was consumed internally in the production of approximately 456,000 tonnes of cement (Ontario Mineral Score, 1987).

Stone production in 1986 for the County of Peterborough amounted to about 95,000 tonnes. The majority of the stone was produced by Ormell Sand and Gravel Limited – Harvey Quarry (L–7) and Harnden and King Construction (Ontario) Limited – Havelock Quarry (L–10) and was consumed in the construction industry as road and concrete aggregate. Building stone accounted for about 650 tonnes.

Stone production in the County of Haliburton in 1986 was approximately 7,000 tonnes, the majority being produced by Bolenders Limited – Eagle Lake Marble Quarry (L–11). The marble is used for landscaping stone, poultry grit, stucco and sand traps for golf courses.

## L–1 ST. MARYS CEMENT COMPANY – BOWMANVILLE QUARRY AND PLANT

### LOCATION AND OWNERSHIP

St. Marys Cement Company operates a quarry and a two-kiln wet process cement plant south of Highway 401 at Bowmanville, approximately 68 km east of Toronto (Figure L–1–1).

The operations are located in Lots 12–17, Broken Front Concession, Town of Newcastle (Darlington Township), Regional Municipality of Durham.

The quarry licence covers an area of 252.38 ha. The cement plant began production in November, 1968, with a single kiln and was expanded in 1974 with the addition of a second kiln. Current annual cement capacity is 650,000 tonnes. At the time of printing the company had announced a further expansion of the plant.

### GEOLOGY

The quarry exposes 50.3 m of the Middle to Upper Ordovician Lindsay Formation (Figure L–1–2), the uppermost lift of 4.3 m consisting of the Collingwood Member. This is the only operating quarry in southern Ontario where the Collingwood Member is exposed.

The lower three lifts expose 46.0 m of the lower member which, in this quarry, consists of interbedded bioclastic calcarenites, microcrystalline limestones and grey-green calcareous mudstones. The mudstones and calcarenites occur mostly in the lower portion of the quarry. The upper part of this member is primarily a microcrystalline limestone.

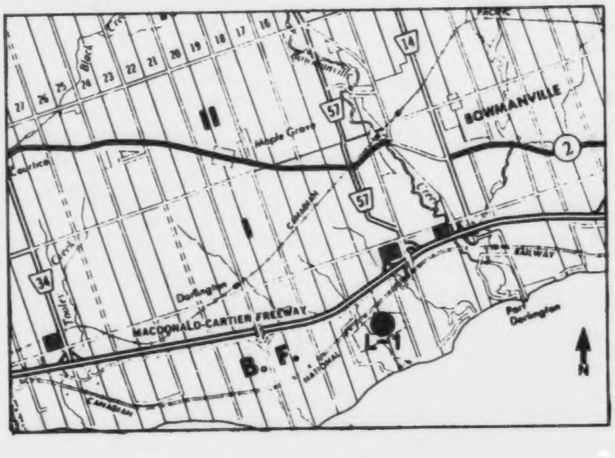


Figure L–1–1. LOCATION MAP FOR BOWMANVILLE QUARRY.

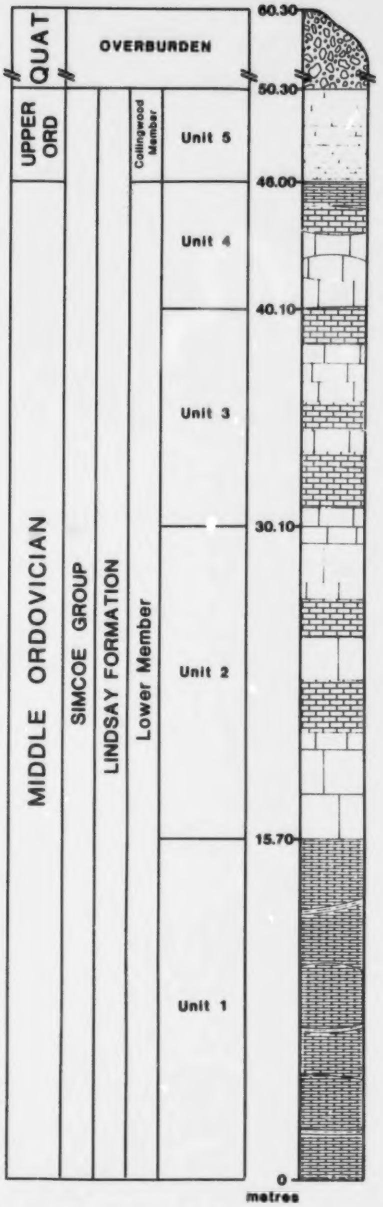


Figure L-1-2. STRATIGRAPHIC COLUMN FOR BOWMANVILLE QUARRY.

The overlying Upper Ordovician Collingwood Member consists of a calcareous, petroliferous, black shale. The shales are profusely fossiliferous and the quarry is well known for its excellent trilobite fossils. Vertical joints are well developed in the upper lift of the quarry. The glacial overburden around the quarry varies from 7 to 11 m thick.

## Geological Section

*Thickness*

*UNIT 5 Lindsay Formation, Collingwood Member* *4.3m*

Calcareous shale: black, weathers light grey; very fissile and platy when weathered, thick bedded, blocky appearance on fresh surfaces; some coarser grained laminae with fossil debris; strong petroliferous odor; prominent jointing (near vertical) occurring approximately every metre; rare iron staining; very fossiliferous, with trilobites most abundant; lower contact of unit sharp and irregular at top of third lift.

*UNIT 4 Lindsay Formation, lower member* *5.9m*

Limestone: medium to dark brown, weathers light grey; microcrystalline to very fine crystalline; medium to thick (20-60 cm) bedded, becomes thinner at top of unit, sharp, very irregular, undulatory contacts; very nodular appearance due to rubbly weathering; upper half of unit contains seven prominent shale beds (2 to 10 cm thick); rare, thin, coarser grained beds, usually with fossil debris; fossiliferous including trilobites and brachiopods, rare rugose corals; lower contact of unit sharp.

*UNIT 3 Lindsay Formation, lower member* *10.0m*

Limestone: dark grey, weathers light grey; microcrystalline, with irregular patches of coarse-grained calcarenites; medium to thick bedded (10 to 70 cm), sharp, slightly irregular contacts with some minor shale partings; nodular texture throughout unit, commonly associated with patches of calcite crystals; shale beds are more abundant upwards and two very prominent shale beds occur at the top of unit; very fossiliferous with abundant trilobites and brachiopods, lower contact of unit gradational, at top of 2nd lift.

*UNIT 2 Lindsay Formation, lower member* *14.4m*

Limestone: medium to dark brown, weathers mottled light grey and green, and grey-brown; microcrystalline limestone and coarse-grained calcarenites; medium to thick bedded (10-100 cm), sharp, slightly irregular contacts, rarely welded contacts; most beds in unit weather into nodules; fossiliferous with abundant brachiopods, trilobites, and rugose corals on bedding planes of the microcrystalline limestones, and abundant fossil fragments in calcarenites; lower contact sharp, at top of 1st (lowest) lift.

*UNIT 1 Lindsay Formation, lower member* *15.7m*

Interbedded limestone and mudstones:

calcareous mudstones - grey, weathers green-grey; thin bedded (3-6 cm), contacts are irregular and undulatory; nodular appearance due to draping of mudstones over coarser calcarenite beds; fossils present on bedding planes;

bioclastic limestones - medium to dark brown, weathers grey-brown; coarse to very coarse crystalline; thin bedded (3-6 cm), in beds that pinch and swell, sharp irregular contacts; very fossiliferous (brachiopods and trilobites, some crinoidal debris);

microcrystalline limestones - dark grey, weathers light grey; thin bedded (about 5 cm); barren of fossils;

in upper part of unit, mudstones decrease in abundance and the unit becomes mainly interbedded calcarenites and microcrystalline limestones; calcite mineralization present along vertical fractures.

*Total thickness* *50.3m*

In 1979 an exploration diamond drill program was carried out within the licence area and St. Marys Cement

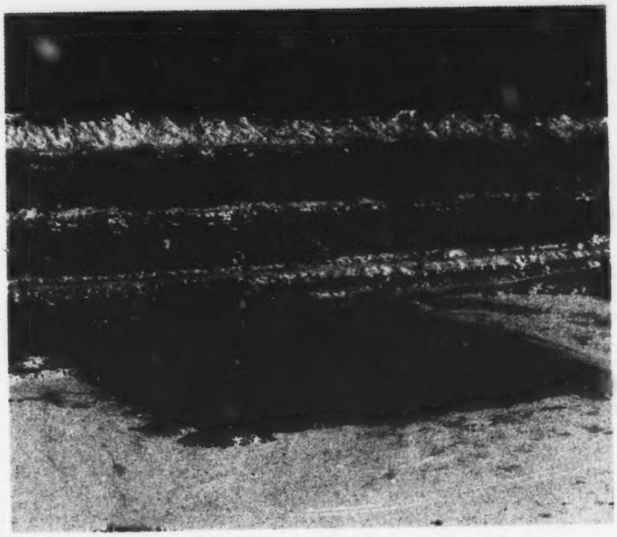


Photo L-1-1. VIEW OF THE QUARRY SHOWING THE THREE BENCHES; BOWMANVILLE QUARRY.

reports that the chemical analyses of drill core, from hole 79-1 (Table L-1-1), are representative of the chemical composition of the underlying stratigraphy.

## QUARRY OPERATION

The quarry operates on three 16.7 m benches. The quarry provides a natural cement stone through blending of the high, medium and low carbonate rock representative of the various benches. Drilling is by a 12.7 cm hydraulic rotary drill on a 4.3 m x 4.9 m pattern using a slurry plus AN/FO at a rate of 0.15 kg/t. Two 10 yd. 992 CAT loaders are used to load five 45-ton rear-dump Euclid trucks which deliver the stone to the primary crusher. The stone is separated by carbonate content at the blasting site.

Table L-1-1. TYPICAL CHEMICAL ANALYSES (%) OF DRILL CORE FROM HOLE 79-1.

| | 10-55 ft. | 55-110 ft. | 110-165 ft. | 165-220 ft. | 220-305 ft. |
|---|---|---|---|---|---|
| Loss | 36.65 | 34.99 | 34.99 | 35.68 | 34.47 |
| $SiO_2$ | 11.82 | 13.82 | 13.82 | 11.50 | 14.18 |
| $Al_2O_3$ | 3.37 | 3.34 | 3.77 | 3.22 | 4.18 |
| $Fe_2O_3$ | 1.0 | 1.12 | 1.36 | 1.44 | 1.49 |
| CaO | 43.36 | 43.23 | 41.54 | 43.69 | 41.59 |
| MgO | 1.82 | 1.96 | 2.13 | 1.68 | 1.64 |
| $SO_3$ | .31 | .34 | .64 | 1.19 | .88 |
| $Na_2O$ | .16 | .16 | .18 | .12 | .12 |
| $K_2O$ | .83 | .89 | .97 | .83 | 1.07 |
| $P_2O_5$ | .065 | .037 | .045 | .052 | .050 |
| $TiO_2$ | .18 | .17 | .18 | .15 | .17 |
| Cl | .032 | .079 | .095 | .090 | .067 |
| F | .021 | .019 | .026 | .019 | .021 |
| $C_3S$ | 62.6 | 46.9 | 36.8 | 66.8 | 31.3 |
| $C_3A$ | 7.1 | 7.0 | 7.7 | 6.1 | 8.6 |
| $C_4AF$ | 3.3 | 3.4 | 4.1 | 4.4 | 4.5 |

## PROCESSING

Primary crushing is achieved by a 54 in. Traylor gyratory crusher having a capacity of 900 tons per hour. The crushed material is separated by carbonate designation and transferred via a feeder/conveyor system to a rock storage area.

Material reclaimed from the rock storage area is processed through a closed circuit secondary 450 KW Pennsylvania 3-hammer crusher which reduces the material to -3/4 in. size at a rate of 500 tons per hour. The screening and conveying systems allow the rock to be separated by calcium carbonate content, and stored in feed silos adjacent to the raw mill operation. Special high carbonate rock from Coboconk, Ontario is used as a calcareous component for the manufacture of low alkali cements.

Blending of the stone and raw grinding takes place in an F.L. Smidth 12 ft. x 34 ft. ball mill. The raw grind slurry is pumped to one of three storage tanks. The two original tanks built in 1967 are 25 ft. high x 80 ft. diameter and hold approximately 735,000 gallons.

The plant has two identical F.L. Smidth kilns, one built in 1964 and the other in 1973. Each kiln is 485 ft. long and 15 3/4 ft. in diameter at the feed end and 14 ft. diameter at the discharge end. Both kilns are coal fired and each has a capacity of 1,000 tons per day. Coal is dried and powderized in an F.L. Smidth ball mill.

Clinker cooling is by a Folax grate cooling system for kiln #1 and a planetary cooling system for kiln #2.

Cooled clinker is transported by belt conveyor to either a 45,500 tonne storage silo or to four 1,400 tonne feed storage silos. It is drawn from these locations by conveyor and fed to either of two identical F.L. Smidth ball mills with the addition of 5% gypsum. The 2,750 hp. mills are of the 2 chamber type and have overall dimensions of 12 ft. x 34 ft. O-SEPA air classifiers are used in closed circuit with the finish mills, which have a combined capacity of 2,270 tonnes per day. Finished cement is transferred to the storage silo by pneumatic fluxo pumps.

The 11 main and 2 interstice cement storage silos have a total storage capacity of 70,000 tons. Shipping is primarily by bulk truck, with rail loading also available.

Dust control is effected by 31 bag type dust collectors installed throughout the plant. Electrostatic precipitators supplied by Joy Manufacturing are fitted to the kilns to clean exit gases. Bag-type dust collectors are fitted to the two finish mills to clean exhaust gases.

Photo L-1-2. ST. MARYS CEMENT, BOWMANVILLE PLANT *(Courtesy St. Marys Cement Co.)*.

The cement plant is controlled by a Bailey Meter Abacus digital system installed in 1973. This system is interfaced with a Bailey Meter 750 Data Logger analog system installed in 1968.

The company has a wharf facility to receive coal, gypsum and slag, and to ship clinker. Slag is dried and crushed for aggregate use in a ready-mix plant located adjacent to the cement plant.

### PRODUCTS

Normal Portland
High Early Strength Portland
Sulfate Resisting Portland
Moderate Portland
Low Heat of Hydration Portland
Masonry Cement

### REFERENCES

Hewitt and Vos, 1972, p.42–43
Winder et al., 1975, p. 138
Kobluk and Brookfield, 1982, p.29–30
Russell and Telford, 1983
ARIP 94, 1984, pp.13, 21

### MAPS

None

## L–2 MILLER PAVING LIMITED — DALRYMPLE QUARRY

### LOCATION AND OWNERSHIP

The Dalrymple Quarry is located 3 km south of Dalrymple, in Lots 8–12, Concessions 2 and 3, Carden Township, Victoria County (Figure L–2–1). The quarry licence covers an area of 332.1 ha and production of crusher run and clear stone was started in 1986 by the present operator, Miller Paving Limited. The annual capacity of the quarry has not yet been established but is estimated to be in a range of 100,000 to 250,000 tonnes. Testing of the quarry stone is presently underway to determine the potential for the production of high grade asphalt and concrete stone products. The major market for the quarry products is in eastern Toronto, with all shipping by truck (contracted).

### GEOLOGY

The 6.7 m deep quarry exposes limestones of the upper member, Bobcaygeon Formation. The beds of fine– to medium–crystalline limestones thin from 40–50 cm thick in the lower unit to 5–15 cm thick in the upper unit. Glacial overburden around the quarry is less than 1 m thick.

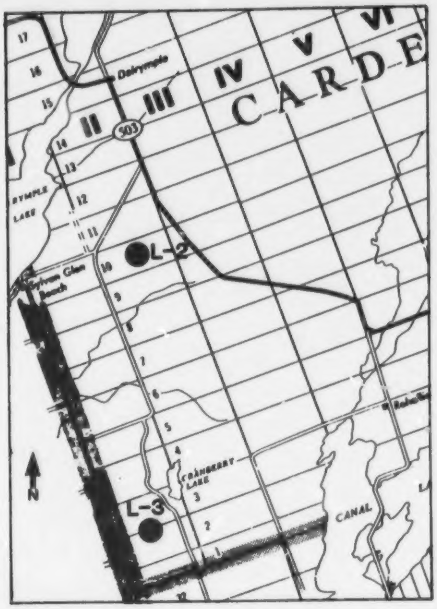


Figure L-2-1. LOCATION MAP FOR DALRYMPLE QUARRY.

### Geological Section

*Thickness*

*UNIT 2 Bobcaygeon Formation, upper member* *5.5m*

Limestone: light to medium grey, weathers light grey; fine crystalline, with rare beds of coarse-grained calcarenites; thin to medium bedded (5-15 cm), sharp, irregular contacts which cause beds to pinch and swell, with shale partings up to 2 cm thick; upper 50 cm of unit lighter grey, coarse-grained calcarenite; small patches of calcite crystals rare; very fossiliferous, and abundant burrows, especially on bedding planes; lower contact of unit sharp at base of lowest shale parting.

*UNIT 1 Bobcaygeon Formation, upper member* *1.2m*

Limestone: mottled medium grey-brown and medium brown, weathers same; very fine and medium crystalline; thick bedded (40-50 cm), sharp and planar contacts with no shale partings; uppermost bed a 5 cm thick, very coarse-crystalline, bioclastic limestone with a very irregular basal contact; abundant calcite crystals, commonly as recrystallized brachiopod shells; fossiliferous with rare brachiopods and gastropods, abundant fossil fragments, and abundant burrows.

*Total thickness* *6.7m*

### QUARRY OPERATION

The quarry is opened on a single lift of 6.7 m and drilled on a 2.7 m x 2.7 m pattern with 7.6 cm diameter blast holes. Shot rock is loaded and hauled by a Fiat-Allis FR35 (6 1/2 yd.) loader to a portable crushing and screening plant (in-pit). Primary crushing is by a 36 in. x 54 in. impact crusher. The crushed stone feeds a scalping screen followed by a Pioneer 5 ft. x 16 ft. double-deck screen, producing clear and crusher run stone. Oversize from the Pioneer screen is sent for secondary crushing by a Nordberg 4 1/2 ft. cone crusher, producing HL8 and screenings.

### PRODUCTS

Crusher Run
Clear Stone
HL8
Screenings

### REFERENCES

ARIP 48, 1981, p. 19

### MAPS

None

## L-3 GORMLEY AGGREGATES LIMITED — CARDEN QUARRY

### LOCATION AND OWNERSHIP

The Carden Quarry is located 11 km south of Dalrymple in Lots 1 to 4, Concession 1, Carden Township, Victoria County (Figure L-3-1). The quarry has been active since February of 1977, opened and operated by the present owner, Gormley Aggregates Ltd. The Carden

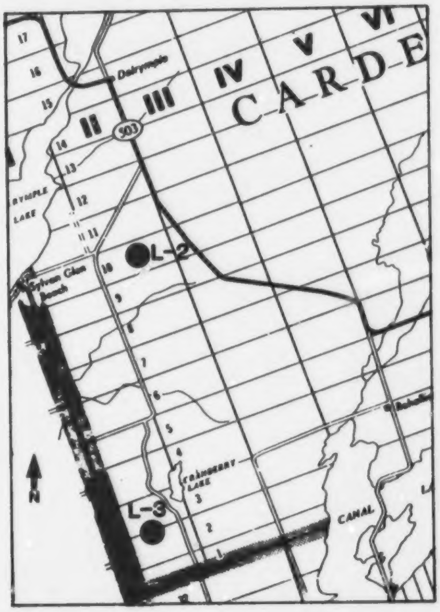


Figure L-3-1. LOCATION MAP FOR CARDEN QUARRY.

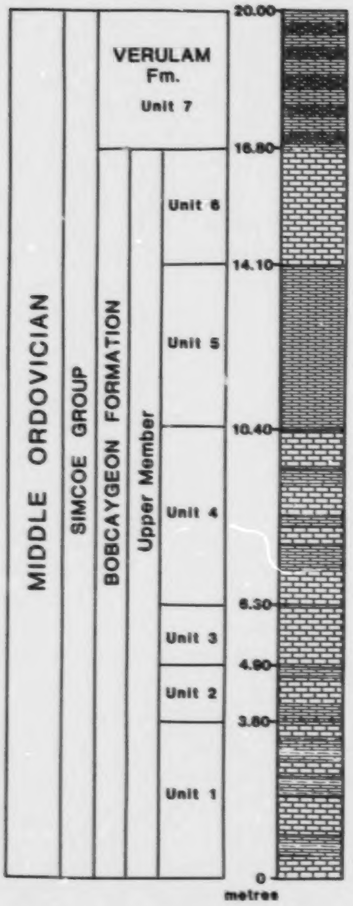


Figure L-3-2. STRATIGRAPHIC COLUMN FOR CARDEN QUARRY.

Quarry operates year round and has a licensed area of 218.4 ha. Stone produced at the quarry is primarily used to supply markets in the eastern region of Toronto. All shipping is by truck (contracted) within an average delivery distance of 100 km.

## GEOLOGY

The two lifts in the quarry expose 20.0 m of section, with 16.8 m of limestones of the Bobcaygeon Formation (upper member) underlying 3.2 m of limestone and shale of the Verulam Formation (Figure L-3-2). The medium-bedded, relatively shale-free, fine- to medium-crystalline limestones and interbedded coarse-grained calcarenites, typical of the upper member of the Bobcaygeon Formation, gradually become thinner bedded with shale interbeds increasing in thickness and frequency to the top of the quarry. The overlying 3.2 m of the Verulam Formation consist of thin-bedded limestones that are interbedded with 2–5 cm thick intervals of shale. Glacial overburden around the quarry is generally less than 0.5 m thick.

### Geological Section

*Thickness*

*UNIT 7 Verulam Formation 3.2m*

Interbedded limestone and shale: medium grey, weathers light grey to light brown in upper 0.5 m; alternating fine and coarse crystalline; thin bedded (2–10 cm) limestone, shale beds thinner (2–5 cm) than limestone beds, sharp, planar and slightly irregular contacts; fossiliferous with abundant brachiopods and fossil fragments; lower contact of unit sharp, at base of soft recessive shale bed.

*UNIT 6 Bobcaygeon Formation, upper member 2.7m*

Limestone: light grey-brown, weathers same; medium to coarse crystalline; medium bedded (10–15 cm), sharp, slightly irregular contacts; sparsely fossiliferous, some burrows; lower contact of unit sharp and planar.

*UNIT 5 Bobcaygeon Formation, upper member 3.7m*

Limestone: light grey-brown to medium grey, weathers same; alternating fine and coarse crystalline; thin bedded (5 cm), sharp contacts, with shale partings up to 1 cm thick; 70 cm above base of unit 10 cm thick bed of very coarse-grained calcarenite with dark grey and black patches, possibly of bitumen; calcite crystals occur in small patches; fossiliferous with abundant brachiopods, some bryozoans, and some burrows; lower contact of unit sharp at base of 8 cm thick, recessive shale bed.

*UNIT 4 Bobcaygeon Formation, upper member 4.1m*

Limestone: medium grey-brown, weathers light grey-brown; alternating fine and coarse crystalline; thin bedded (5–10 cm), sharp, irregular contacts, with minor shaly partings; 1 m above base of unit in coarse-grained calcarenite is a 6 cm thick interval with black chert nodules; 1.3 m above base of unit is a light grey-green, soft, recessive shale; calcite-filled vugs in some coarser crystalline beds; intraclasts of fine-crystalline limestone in coarser crystalline beds; fossiliferous with some brachiopods, rare bryozoans and abundant burrows, especially on bedding planes; lower contact of unit sharp at top of lower lift.

*UNIT 3 Bobcaygeon Formation, upper member 1.4m*

Limestone: light grey, weathers lighter grey; fine to medium crystalline; medium bedded (15 cm), sharp, irregular contacts; several beds of coarse-grained calcarenites scattered throughout unit (2 cm thick bed 5 cm above base, 10 cm thick bed 1.0 m above base, 10 cm thick bed 1.3 m above base); the bed at top of unit very coarse-grained calcarenite, with abundant fossil fragments, and large, black chert nodules; small calcite crystals throughout unit; sparsely fossiliferous with rare brachiopods; lower contact of unit sharp, at a thin shaly limestone parting.

*UNIT 2 Bobcaygeon Formation, upper member 1.1m*

Limestone: light grey, weathers same; fine crystalline; thin bedded (5–10 cm), sharp, very irregular contacts; 20 cm above base of unit is a soft, recessive shale, 5 cm thick; small vugs present, some filled with calcite crystals; fossiliferous with abundant brachiopods and bryozoans, burrows rare; lower contact sharp at base of thin, shaly limestone parting.

*UNIT 1 Bobcaygeon Formation, upper member* *3.8m*

Limestone: light grey-brown, weathers grey-brown to light brown; medium crystalline; thin to medium bedded (5-25 cm), sharp, irregular contacts with very thin, dark grey shaly limestone partings; near top of unit is a 5 cm thick coarse-grained calcarenite with a sharp erosional base; small vugs filled with calcite crystals present in some beds; fossiliferous with abundant bryozoans (*Prasopora*), brachiopods, rugose corals, and some burrows.

*Total thickness* *20.0m*

## QUARRY OPERATION

The quarry is presently worked on a single lift of 9.45 m to 14.6 m using a 3.7 m x 3.7 m drill pattern with 10.2 cm diameter blast holes. Drilling is done by an ROC812HCS Atlas Copco. Normal quarry conditions are dry; a 6 in., 30 hp. Flygt submersible pump handles all quarry dewatering (run-off). AN/FO is used as much as possible for blasting, initiated with electric caps. Shot rock is loaded by two 8 yd. Michigan L320 loaders.

## PROCESSING

The broken rock is dumped into a primary 53 in. x 48 in. Cedarapids single impeller crusher, which reduces the rock to −8 in. This product is carried by 36 in. conveyor and a stacker to a surge bin that feeds a 5 ft. x 12 ft. double-deck screen. Plus 5 in. oversize from this screen is routed to either a gabion stone stockpile or a 36 in. x 45 in. Cedarapids twin impeller secondary crusher (Figure L-3-3).

Plus 7/8 in. stone from the screen is fed to a second double-deck screen, which routes the +2 1/2 in. oversize to a Spokane vertical impact crusher. The product of the Spokane crusher joins that of the secondary Cedarapids crusher. Minus 2 1/2 in. intermediate stone is either stockpiled as 2 in. clear or added to the crusher run blending belt. The fines from this second screen are added to the fines from the first screen, blended and stockpiled as 3/4 in. or 2 in. crusher run.

The products of the two secondary crushers are fed to twin 6 ft. x 16 ft. Dillon screens, from which a +1 1/8 in. oversize is returned to the Spokane crusher. From the first deck, a 3/4 in. clear stone is produced, second deck produces HL8, or the product is rescreened on a 4 ft. x 8 ft. double-deck Dillon screen to produce 3/8 in. clear and HL8. The fines from the two Dillon screens are added to the blending belt conveyor and sent to the

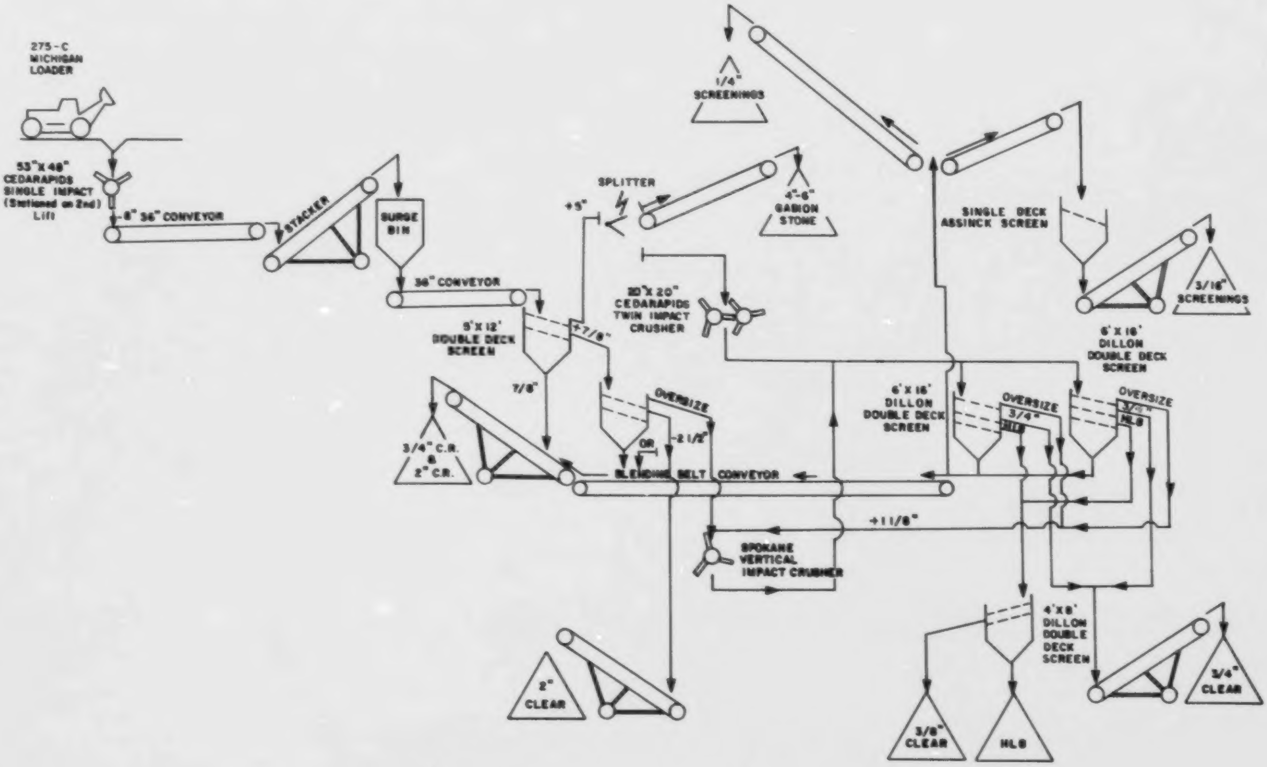

275-C MICHIGAN LOADER
53"X 48" CEDARAPIDS SINGLE IMPACT (Stationed on 2nd) Lift
-8" 36" CONVEYOR
STACKER
SURGE BIN
36" CONVEYOR
5'X 12' DOUBLE DECK SCREEN
+7/8"
7/8"
3/4" C.R. & 2" C.R.
SPLITTER
+5"
4"-6" GABION STONE
1/4" SCREENINGS
20"X 20" CEDARAPIDS TWIN IMPACT CRUSHER
OVERSIZE
OR
-2 1/2"
BLENDING BELT CONVEYOR
SPOKANE VERTICAL IMPACT CRUSHER
+1 1/8"
2" CLEAR
SINGLE DECK ASSINCK SCREEN
3/16" SCREENINGS
6'X 16' DILLON DOUBLE DECK SCREEN
OVERSIZE
3/4"
HL8
6'X 16' DILLON DOUBLE DECK SCREEN
OVERSIZE
3/4"
HL8
4'X 8' DILLON DOUBLE DECK SCREEN
3/8" CLEAR
HL8
3/4" CLEAR

**Figure L-3-3. PROCESS FLOW SHEET FOR CARDEN QUARRY.**

crusher run stockpiles or stockpiled as 1/4 in. screenings or rescreened by a 4 ft. x 12 ft. Assinck screen to produce –3/16 screenings.

### PRODUCTS

Gabion Stone
Shot Stone
2 in. Crusher Run
3/4 in. Crusher Run
HL3, HL8
Riprap
2 in. Clear
3/4 in. Clear
3/8 in. Clear
1/4 in. Screenings
3/16 in. Screenings

### REFERENCES

ARIP 48, 1981, p. 19

### MAPS

None

## L–4 CEDARHURST CRUSHING & QUARRIES LTD. — COBOCONK EAST QUARRY

### LOCATION AND OWNERSHIP

The Coboconk East Quarry is located within the village of Coboconk on Highway 35, in Lots 37 and 38, Front Range Concession, Somerville Township, Victoria County (Figure L–4–1). The property has intermittently produced lime since the turn of the century, and was purchased in 1972 from Indusmin Ltd. by the present owner and operator, Cedarhurst Crushing & Quarries Ltd., a subsidiary of K. J. Beamish Construction Co. Ltd. of Thornhill, Ontario.

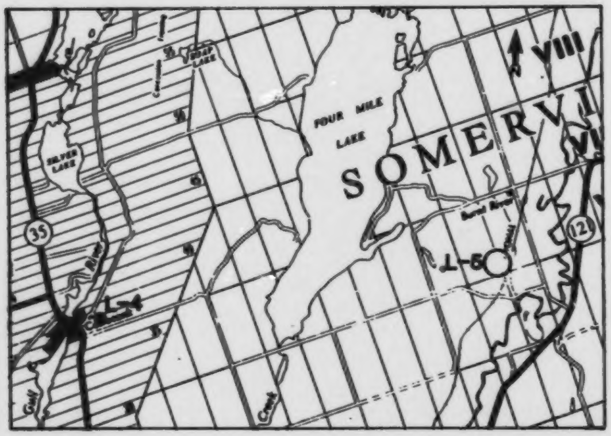


**Figure L–4–1. LOCATION MAP FOR COBOCONK EAST QUARRY.**

No significant quantity of aggregate stone was extracted from the Coboconk Quarry until 1986. The quarry is scheduled to steadily expand production levels.

On the western side of Highway 35, just south of Coboconk, is the abandoned Coboconk West Quarry (Goudge, 1938) which exposes a similar section to the East Quarry. The old lime kilns still stand near the western quarry.

### GEOLOGY

The 9.5 m deep Coboconk East Quarry exposes thick–bedded limestones which are assigned to the lower member, Bobcaygeon Formation, as defined by Williams (in prep.). Liberty (1969, p. 156–157) had placed the lower part of the quarry section into the upper member of the Gull River Formation. The strata in the quarry consist of grey–brown, thick–bedded, microcrystalline (commonly with a lithographic texture) to medium–crystalline limestones, with intervals of medium–to coarse–grained calcarenites. Most beds are moderately fossiliferous. Glacial overburden on the crest of the hill where the quarry is located is generally less than 1.0 m thick.

### Geological Section

*Thickness*

*UNIT 4 Bobcaygeon Formation, lower member 2.7m*

Limestone: medium grey, weathers light grey to light brown at top; fine to medium crystalline; thin bedded (5–10 cm), upper beds thinner bedded, with sharp, very irregular contacts, some stylolitic; 80 cm thick interval, 1.3 m above base, with very thin beds of medium grey, very fine–crystalline limestone; uppermost 60 cm, medium- to coarse–grained calcarenite; small calcite–filled vugs present in some beds; very fossiliferous; lower contact of unit sharp and irregular.

*UNIT 3 Bobcaygeon Formation, lower member 3.5m*

Limestone: dark grey and grey–brown, weathers same; fine to coarse crystalline, becoming coarser crystalline at top of unit; thin to medium bedded (5–15 cm), with sharp, irregular contacts, commonly coated with thin, black organic–rich layers; numerous small, calcite–filled vugs and patches in coarser crystalline horizons; rare, large calcite–filled vugs in uppermost 40 cm; fossiliferous, with abundant bryozoans, brachiopods and crinoidal debris; horizontal burrows common on bedding plane surfaces; lower contact of unit sharp and irregular.

*UNIT 2 Bobcaygeon Formation, lower member 1.0m*

Limestone: medium grey–brown, weathers grey–brown; very coarse–grained calcarenite; medium bedded (10–20 cm) with sharp irregular contacts, commonly with thin, black organic–rich coatings; small calcite–filled vugs abundant; numerous indeterminant fossil fragments; lower contact of unit varies from sharp, slightly irregular to gradational over 5 cm.

*UNIT 1 Bobcaygeon Formation, lower member* *2.3m*

Limestone: dark grey-brown, weathers medium grey-brown; microcrystalline, with a lithographic texture; thick bedded (30–60 cm), sharp, stylolitic contacts, commonly coated with a thin, black organic-rich layer; 20 cm thick bed, 1.9 m above base of unit, of very coarse-grained calcarenite; small patches of calcite crystals ("birdseye" texture) common, especially in lower part of unit.

*Total thickness* *9.5m*

### QUARRY OPERATION

The quarry is currently excavated on a single lift of 9.1 m, over an area of about 4 ha. Drilling and blasting is subcontracted. A drill pattern of 2.4 m x 2.4 m with 7.6 cm diameter blast holes is used.

Crushing equipment includes a 30 in. x 42 in. Pioneer jaw and LJ Standard and LJ Shorthead cone crushers (with screens).

### PRODUCTS

Riprap
Granular "A"
1 1/4 in. Clear
1/2 in. Clear
3/4 in. Clear
Screenings
Shot Stone
HL 8
HL 3

### REFERENCES

Goudge, 1938, p. 198–201
Okulitch, 1939
Caley and Liberty, 1952b, p. 7
Hewitt, 1960, p. 42–44
Hewitt, 1964a, p. 28
Mirynech and Liberty, 1964, p. 28–29
Schoft, 1966, p.27
Liberty, 1969b, p. 155–158
Sabina, 1970, p. 148
Winder and Sanford, 1972, p.55

### MAPS

Caley and Liberty, 1952a, GSC Map 52–31A
Liberty, 1969a, GSC Map 1228A

## L–5 BRITNELL QUARRY

### LOCATION AND OWNERSHIP

This abandoned quarry is located in Lot 13, Concession 6, Somerville Township, Victoria County, 1 km south of the village of Burnt River (Figure L–5–1). It is a very old quarry dating back to the turn of the century when it was used for building and crushed stone (Parks, 1912).

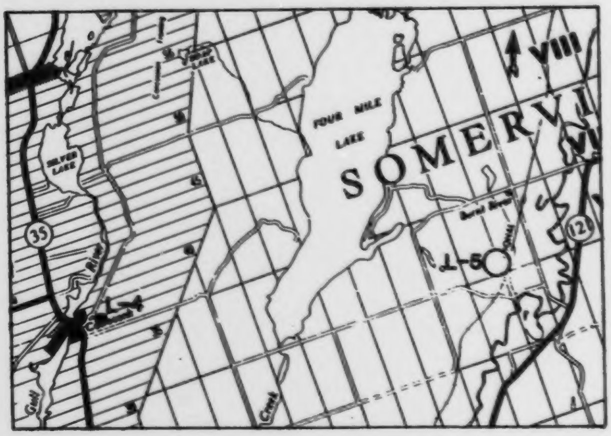


Figure L-5-1. LOCATION MAP FOR BRITNELL QUARRY.

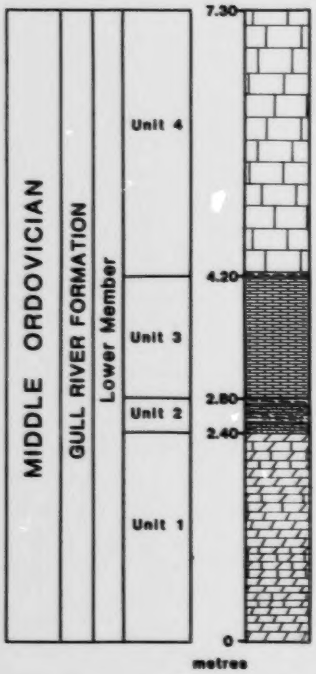


Figure L-5-2. STRATIGRAPHIC COLUMN FOR BRITNELL QUARRY.

### GEOLOGY

The geological section consists of 7.3 m of dolostone and limestone of the lower member, Gull River Formation (Figure L–5–2). Due to their distinctive red colour, the rocks in the lower portion of this quarry have been referred to by the building stone trade as the "Red Pamelia" stone, and were primarily used for building stone. Glacial overburden around the quarry is generally less than 1 m thick.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 4 Gull River Formation, lower member* | *3.1m* |
| Limestone: light to medium grey and light grey-brown, weathers light grey, upper 0.5 m weathers into rubble; microcrystalline with a lithographic texture; thick bedded (40–70 cm), sharp, planar to stylolitic contacts; 0.7 m thick bed, 1.8 m above base of unit, of medium grey, fine-crystalline limestone; small patches of calcite crystals; thin coatings of glauconite on bedding planes, stylolites and burrows; sparsely fossiliferous, with some burrows also; lower contact of unit sharp at 1 cm thick shaly limestone bed. | |
| *UNIT 3 Gull River Formation, lower member* | *1.4m* |
| Limestone: light to medium grey, weathers cream to light grey; microcrystalline, with a lithographic texture, thin (3–10 cm) and very evenly bedded, sharp, stylolitic contacts or with very thin shale partings; lower contact of unit sharp at recessive, soft green shale bed. | |
| *UNIT 2 Gull River Formation, lower member* | *0.4m* |
| Interbedded shale and sandy limestone: alternating red and green, weathers same; fine-crystalline limestone with very coarse-grained quartz sand; very thin bedded (1–3 cm) with sharp, planar contacts; lower contact of unit sharp and planar. | |
| *UNIT 1 Gull River Formation, lower member* | *2.4m* |
| Interbedded dolostone and calcareous dolostone: red to reddish grey, weathers red to reddish brown: "Red Pamelia" stone; fine crystalline; medium bedded (10–30 cm), sharp, planar contacts with occasional very thin dolomitic shale partings; lower 0.5 m covered by talus. | |
| *Total thickness* | *7.3m* |

### REFERENCES

Parks, 1912, p. 225–227
Goudge, 1938, p. 201
Caley and Liberty, 1952b, p. 7
Hewitt, 1964b, p. 25
Liberty, 1969b, p. 98

### MAPS

Caley and Liberty, 1952a, GSC Map 52–31A
Liberty, 1969a, GSC Map 1228A

## L-6 NELSON WINDOVER — NICHOLS (FLYNNS TURN) QUARRY

### LOCATION AND OWNERSHIP

The Nichols Quarry is located along Highway 36, 6 km west of Flynns Turn in Pt. Lot 21, Concession 13, Harvey Township, Peterborough County (Figure L–6–1). The quarry was opened in 1975 by the present owner and operator Nelson Windover, and is licensed for an area of 13 ha. The quarry is presently producing small amounts of building stone and is opened over an area of less than 0.5 ha to a depth of 1.0 m.

### GEOLOGY

The 1 m deep excavation exposes limestone and red and green sandy, dolomitic limestone from the lowermost Gull River Formation. Overburden is thin.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 1 Gull River Formation, lower member* | *1.0m* |
| Limestone and sandy dolomitic limestone: red to reddish brown and green; fine to medium crystalline with coarse, well-rounded quartz grains; beds up to 30 cm thick, which may weather into 5 cm thick platy sheets in places. | |
| *Total thickness* | *1.0m* |

### QUARRY OPERATION

Overburden is removed by a front end loader. Drilling and blasting is not performed at the quarry as all material is extracted by ripping, using a John Deere 690 backhoe (1 1/2 yd.). The stone ranges in colour from light grey to orange, pink and green and in thickness from 5 cm to 15 cm. The ripped stone is loaded by backhoe into a Volvo 1920 (4 1/2 yd.) front end loader. The stone is then dumped, hand sorted and loaded back into the Volvo bucket. The final building stone product is then transferred to tandem trucks for delivery.

### REFERENCES

None

### MAPS

Carson, 1980, OGS Map P.2337

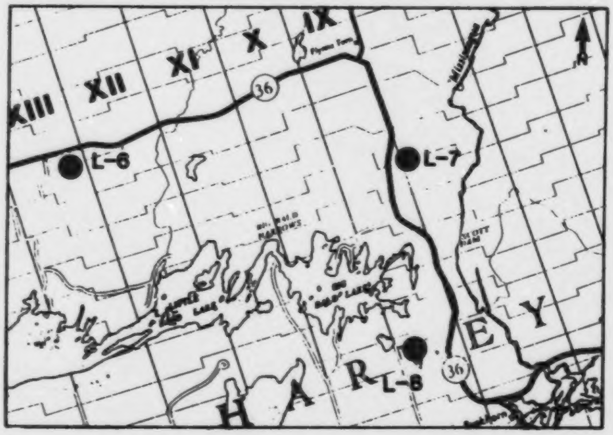


Figure L–6–1. LOCATION MAP FOR NICHOLS (FLYNNS TURN) QUARRY.

## L-7 ORMELL SAND AND GRAVEL LIMITED — HARVEY QUARRY

### LOCATION AND OWNERSHIP

The Harvey Quarry is located 1 km south of Flynns Turn in Lot 17, Concession 9, Harvey Township, Peterborough County (Figure L-7-1). The quarry was opened in 1985 by the present operator, Ormell Sand and Gravel Limited and is licenced over an area of 27 ha.

The quarry principally supplies aggregate within a radius of approximately 40 km (Peterborough area).

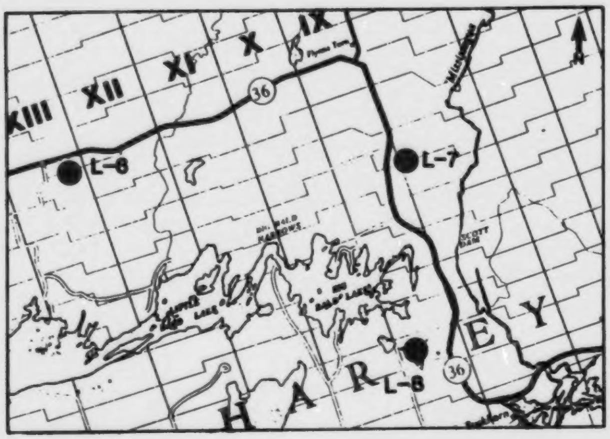


Figure L-7-1. LOCATION MAP FOR HARVEY QUARRY.

### GEOLOGY

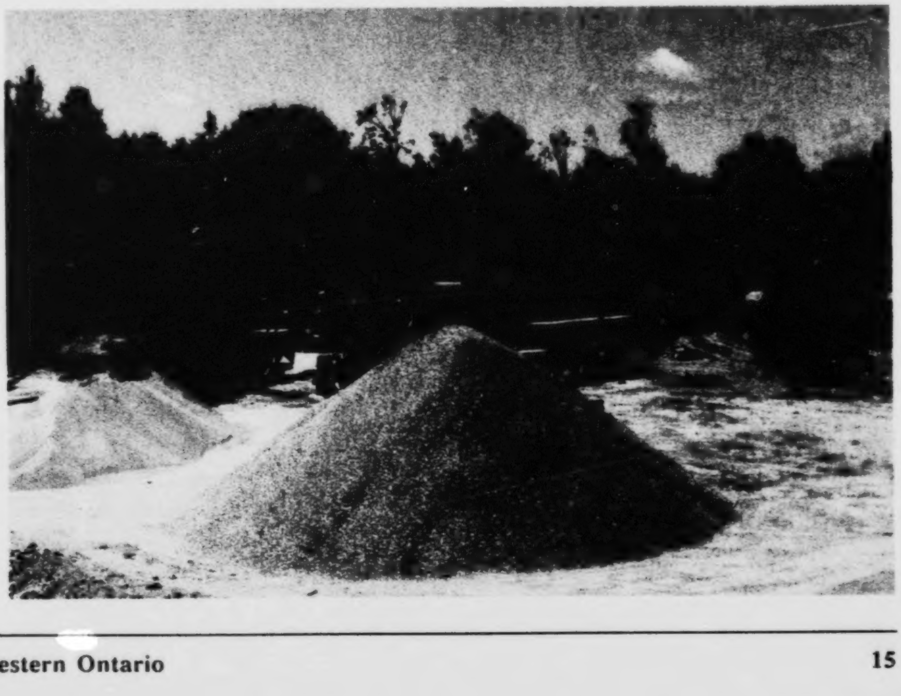
The quarry is located at the south end of a small Paleozoic outlier informally referred to as the Flynns Turn outlier. The 8.2 m face consists entirely of limestone of the lower member of the Gull River Formation. The medium to dark grey, microcrystalline limestone beds are separated by very thin, dark grey, soft, recessive shale partings. Bedding thickens from 30 to 60 cm at the base of the quarry to 80 cm at the top, though blasting in the quarry has commonly split these thicker beds into thinner (10 to 20 cm) horizons. The limestone contains numerous calcite patches typical of “birdseye” texture, and also small, shiny, black, organic–rich patches, associated with black coatings on the bedding planes. Glacial overburden around the quarry is less than 1.0 m thick.

#### Geological Section

| | Thickness |
|---|---|
| *UNIT 2 Gull River Formation, lower member* | *5.1m* |

Limestone: medium to dark grey, weathers grey to light brown; microcrystalline with a lithographic texture; medium to thick bedded (40–80 cm), some contacts stylolitic, others with very thin shale partings; abundant calcite-filled vugs and burrows; small, shiny, black patches throughout, probably bitumen; sparsely fossiliferous with rare corals; lower contact of unit sharp and planar.

Photo L-7-1.
PORTABLE PROCESSING PLANT; HARVEY QUARRY.



*UNIT 1 Gull River Formation, lower member* *3.2m*

Limestone: medium grey, weathers same; microcrystalline with a lithographic texture; thick bedded (30 to 60 cm), sharp contacts with thin, dark grey, soft and clay-like, shale intervals; rare patches of calcite crystals ("birdseye texture"); numerous small diffuse dark grey to black patches, probably bitumen.

*Total thickness* *8.3m*

### QUARRY OPERATION

The quarry is opened on a single lift of 8.2 m, with a drill pattern of 2.1 m x 2.1 m and 63.5 mm diameter blast holes. Drilling and blasting is contracted, but crushing and screening is performed by Ormell Sand and Gravel Limited from April to November, using portable facilities at the quarry.

### PRODUCTS

Gabion Stone
3/4 in. Clear
HL 8
HL 7
HL 4
HL 3

### REFERENCES

None

### MAPS

Carson, 1980, OGS Map P.2337

## L-8 NELSON WINDOVER — HOME (BUCKHORN) QUARRY

### LOCATION AND OWNERSHIP

The Home Quarry is located in Pt. Lot 12, Concession 9, Harvey Township, Peterborough County (Figure L-8-1), and was opened in 1962 by the present owner and operator, Nelson Windover. The Home Quarry is licensed for an area of 2 ha. The quarry is presently producing small amounts of building stone and has a disturbed area of 0.5 ha, to a depth of about 1.9 m.

The quarry is located just northwest of two old, abandoned building stone quarries (Winder, 1954b) that supplied stone for construction of the Trent Canal.

### GEOLOGY

The 1.9 m face consists of limestone from the lower member of the Gull River Formation. Overburden averages about 0.7 m in thickness.

### Geological Section

*Thickness*

*UNIT 2 Gull River Formation, lower member* *1.0m*

Limestone: light to medium grey, weathers same; microcrystalline, with a lithographic texture; single bed with numerous stylolites; abundant burrows, filled with a greenish brown, fine-crystalline dolomitic limestone; lower contact of unit sharp.

*UNIT 1 Gull River Formation, lower member* *0.9m*

Limestone: medium grey-brown, weathers same: fine to medium crystalline; thick bedded (40-45 cm), which easily splits into thin beds (3 to 6 cm thick); scattered large vugs, filled or partially filled with calcite, some also with pyrite or gypsum crystals.

*Total thickness* *1.9m*

### QUARRY OPERATION

Overburden is removed by loader. Drilling and blasting is not performed at the quarry; a John Deere 690 backhoe (1 1/2 yd.) extracts the stone by ripping. The stone is layered in various thicknesses and qualities; it is white to grey and can be very hard. The top three layers, 3 cm, 7.5 cm and 35.5 cm in thickness, are used mainly for retaining wall stone while the bottom (approximately ten) layers, ranging in thickness from 5 to 20 cm are used for fireplace fireboxes (high temperatures). The ripped stone is loaded by a backhoe to a Volvo 1920 (4 1/2 yd.) front end loader and then dumped, hand sorted, and loaded back into the Volvo bucket. The sorted stone is loaded into tandem trucks for delivery.

### PRODUCTS

Retaining wall stone
Fireplace firebox stone

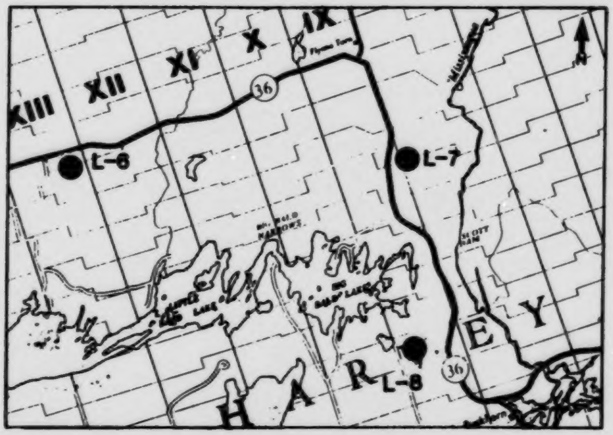


Figure L-8-1. LOCATION MAP FOR HOME (BUCKHORN) QUARRY.

### REFERENCES

None

### MAPS

Winder, 1954b, GSC Map 53-27A (adjacent quarries)

## L-9 ELDRED W. PAYNE — WARSAW QUARRY

### LOCATION AND OWNERSHIP

The Warsaw Quarry is located 9 km northeast of Warsaw in the east half of Lot 21, Concession 4, Dummer Township, Peterborough County (Figure L-9-1). The quarry was opened in 1970 by the present owner and operator, Eldred W. Payne, and is licenced for an area of 11.34 ha. The Warsaw Quarry produces specialty stone products.

### GEOLOGY

The shallow, 0.6 m deep quarry in the lower member of the Gull River Formation, exposes a single bed of microcrystalline limestone. A thin shaly dolostone parting caps the limestone bed. Numerous thin calcite veins, trending northeast–southwest, cross the quarry floor with an average 2 m spacing. Overburden ranges in thickness from about 5 cm to 90 cm.

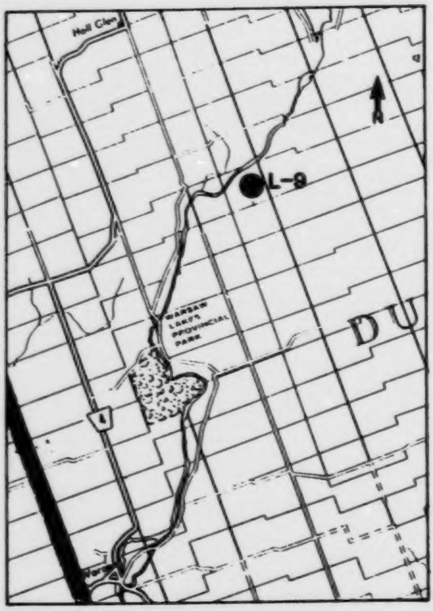


**Figure L-9-1. LOCATION MAP FOR WARSAW QUARRY.**

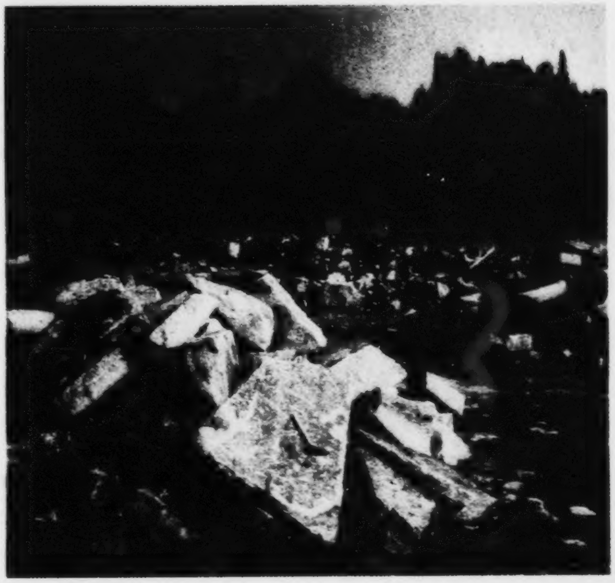


**Photo L-9-1. TYPICAL QUARRY RUN MATERIAL; WARSAW QUARRY.**

### Geological Section

| | *Thickness* |
|---|---|
| *UNIT 1 Gull River Formation, lower member* | *0.6m* |
| Limestone: light grey to grey-brown, weathers light grey; microcrystalline, with a lithographic texture, and scattered patches of very fine crystalline; single bed which splits into two in places; at the top is a thin, light brown silty dolostone parting; numerous, thin vertical calcite veins trending SW-NE with approximately 2 m of separation across quarry floor. | |
| *Total thickness* | *0.6m* |

### QUARRY OPERATION

The quarry has been opened over an area of about 2 ha to a depth of 0.6 m. All stone is extracted by ripping using a John Deere 450-C front-end loader (reinforced bucket). Explosives are not used at the quarry as blasting has been shown to have a deleterious effect on the structural strength of the stone.

Several layers of various thicknesses exist over the 0.6 m quarry depth; each layer is extracted for a particular specialty stone product. The ripped stone is sized by hand into the various products.

### PRODUCTS

- Shoreline stone
- Gabion stone
- Retaining wall stone
- Patio stone
- Driveway stone

### REFERENCES

ARIP 25, 1980, p. 18

### MAPS

None

## L-10 HARNDEN AND KING CONSTRUCTION (ONTARIO) LIMITED — HAVELOCK QUARRY

### LOCATION AND OWNERSHIP

The Havelock Quarry is located 3 km west of Havelock in Lots 8 and 9, Concession 11, Belmont Township, Peterborough County (Figure L-10-1). The quarry is owned by Mr. Ted Smith and is operated by Harnden and King Construction (Ontario) Limited.

The quarry is licensed over an area of 56.7 ha. The Havelock Quarry was opened in 1979 by Harnden and King Construction and is operated on an intermittent basis.

### GEOLOGY

At the time of the field work, the quarry was partially flooded and only 2 m of coarse-crystalline limestone were exposed above the water level. The thin-bedded nature of the exposed limestone suggests that these strata occur in either the middle or upper members of the Bobcaygeon Formation, but the restricted section available makes an exact determination difficult. Overburden averages approximately 1.2 m in thickness.

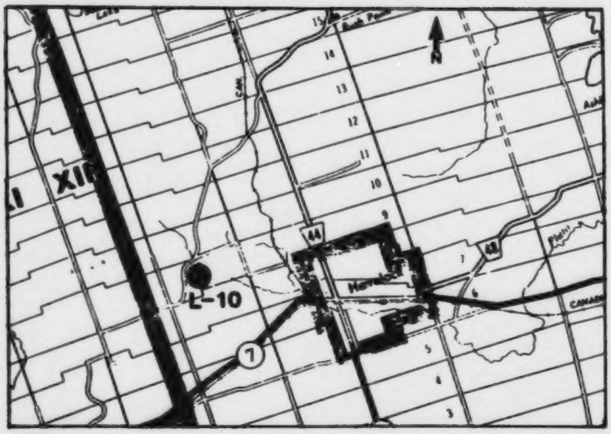


**Figure L-10-1. LOCATION MAP FOR HAVELOCK QUARRY.**

### Geological Section

| | *Thickness* |
|---|---|
| *UNIT 1 Bobcaygeon Formation* | *2.0m* |
| Limestone: medium grey, weathers light to medium grey to blue-grey; coarse crystalline with patches of coarse-grained calcarenite; thin bedded (5-10 cm); very fossiliferous bioclastic limestone. | |
| *Total thickness* | *2.0m* |

### QUARRY OPERATION

The quarry has supplied gabion stone for lakeshore protection in the Cobourg area. Other products include clear and crusher run stone products. Core sampling and testing of the lower (future) level has indicated stone suitable to produce HL4 asphalt stone. A single lift is presently opened to a depth of 7.6 m over dimensions of about 50 m x 100 m.

### PRODUCTS

Gabion stone
Crusher run
Clear stone

### REFERENCES

None

### Maps

None

## L-11 BOLENDERS LIMITED — EAGLE LAKE MARBLE QUARRY

### LOCATION AND OWNERSHIP

Bolenders Limited – Eagle Lake Marble Quarry is located in Minden District on Lot 25, Concession 4, Guilford Township, Haliburton County.

### GEOLOGY

The Eagle Lake Quarry has been opened in the steep west face of a ridge of white, coarse-crystalline Grenville dolomitic marble which hosts black lenses of amphibolite. Minor minerals present include diopside, phlogopite, pyrite, tremolite, serpentine and actinolite. The ridge strikes north-south and dips to the west at 40°.

The physical properties for the marble are reproduced from D.F. Hewitt (1964d, p.17) as follows:

| | | |
|---|---|---|
| Compressive strength, | MPa | |
| | Maximum | 90 |
| | Minimum | 85 |
| | Average | 87 |
| Absorption | | 0.13% |
| Bulk Specific Gravity | | 2.84 |
| Kg/m³ | | 2,825 |
| Abrasive hardness | | 20.5 |

## QUARRY OPERATION

The quarry has been developed by drilling and blasting. The drilling is accomplished with a Gardner–Denver air track. The blasted rock is loaded at the face by a front end loader and transported by truck to the processing plant.

## PROCESSING

The stone is dumped into a primary jaw crusher which reduces the material to −4 in. The stone is further reduced by a secondary jaw crusher, and a tertiary cone crusher which is in closed circuit with triple–deck vibrating screens. The sized products are stored in separate bins and shipped by truck in bags or in bulk.

Production from the quarry is used for landscaping stone and poultry grit. Finer sizes find markets in stucco and sand traps on golf courses.

## PRODUCTS

5/8 in. Marble Chips
3/8 in. Marble Chips
1/4 in. Marble Chips
3/16 in. Marble Chips
1/8 in. Marble Chips
No. 5 Granule
No. 6 Sand

## REFERENCES

Hewitt 1964c, p.17

# Huronia District

## INTRODUCTION

Huronia District is the northernmost district in the Central Region of southern Ontario, adjoining the Districts of Owen Sound to the west, Cambridge and Maple to the south, Minden to the east, and Bracebridge and Parry Sound to the north. The northwest corner of Huronia District is bounded by the waters of Georgian Bay.

Thirty–three quarries in Huronia District are documented in the quarry inventory (*see* Appendix IV, Volume I); six are currently active, three report intermittent production with the balance representing past producing quarries of geological significance.

All of the active and intermittently active quarries, along with several quarries of geological significance, were visited during the study and include the following:

| | |
|---|---|
| *H–1* | *McKean Quarries Limited – Duntroon Quarry (active)* |
| *H–2* | *Duntroon Quarry (abandoned)* |
| *H–3* | *Allan G. Cook Ltd. – Coldwater (Waubaushene) Quarry (active)* |
| *H–4* | *Ministry of Transportation – Medonte (Coldwater) Quarry (intermittent)* |
| *H–5* | *Nelson Aggregate Company – Uhthoff Quarry (active)* |
| *H–6* | *Fowler Construction Co. Ltd. – Woods (Longford) Quarry (active)* |
| *H–7* | *Rama Township Quarry (intermittent)* |
| *H–8* | *Mara Limestone Aggregates Ltd. – Gamebridge Quarry (active)* |
| *H–9* | *Standard Aggregates Ltd. – Brechin Quarry (active)* |
| *H–10* | *C. S. Speiran – Speiran Quarry (intermittent)* |

## REGIONAL GEOLOGY

The Huronia District extends southward from the southeastern end of Georgian Bay to the Orangeville area, encompassing most of Simcoe and Dufferin Counties (Figure H–0–1). The main geomorphic features of the district are the Niagara Escarpment to the west, Georgian Bay in the north, and Lake Simcoe in the east. The area possesses a varied, glacially formed terrain. The Niagara Escarpment is the most prominent bedrock feature, and rises over 200 m above the area to the east.

The thickness of the Quaternary deposits in the district thickens gradually southwestward towards the Escarpment. In the northernmost part of the district a narrow belt of Precambrian rocks is directly overlain by a thin glacial cover.

The Huronia District is underlain by Precambrian, Ordovician and Silurian rocks (Figure H–0–2). Rocks of the Precambrian outcrop in the northernmost portion of the district where limited amounts of aggregate and dimension stone are extracted from several quarries.

The irregular Precambrian–Paleozoic contact has a relief of several metres. Both inliers of Precambrian rock in the Paleozoic and small outliers of Ordovician rocks on the Precambrian surface occur adjacent to the boundary between the Precambrian and Paleozoic. The Coldwater Quarry (H–3) of A.G. Cook Ltd. is located on one of the larger Paleozoic outliers, north of Waubaushene.

The Paleozoic strata underlying the area east of the Niagara Escarpment in the Huronia District consist of Middle to Upper Ordovician rocks. The following units are present (in ascending order): Shadow Lake, Gull River, Bobcaygeon, Verulam, Lindsay, Blue Mountain, Georgian Bay and Queenston Formations.

The Shadow Lake Formation ranges in thickness from zero, where it is absent over Precambrian topographic highs, to 12 m where it infills Precambrian lows. It commonly consists of a basal conglomerate which is overlain by greenish grey, coarse–grained, calcareous sandstone or sandy limestone. The upper part of the formation may also contain red and green sandy shales. The Shadow Lake Formation is not actively quarried in Huronia District although it does occur on the floor of the Rama Township Quarry (H–7).

Overlying the Shadow Lake Formation are the Middle Ordovician limestones collectively referred to as the Simcoe Group, which include (in ascending order): the Gull River, Bobcaygeon, Verulam, and Lindsay Formations.

The Gull River Formation in this district has been subdivided into the lower, middle and upper members by Liberty (1969b). The lower member is up to 15 m thick and is characterized by fine–crystalline, grey to greenish grey, dolomitic limestones and calcareous dolostones. The middle member is 8 to 9 m thick and consists of microcrystalline limestone (commonly with a lithographic texture), which is light grey to white in colour. Common in the middle member are small patches of calcite crystals termed "birdseye" texture. The upper member is up to 3 m thick and consists of grey, microcrystalline to fine–crystalline limestone. East of Huronia District, the upper member of the Gull River Formation has been included with the lower member of the overlying Bobcaygeon Formation, as redefined by Williams (in prep.).

The Gull River Formation is extensively quarried in the Huronia District. Strata of the Gull River Formation can be observed in the Coldwater (H–3), Medonte

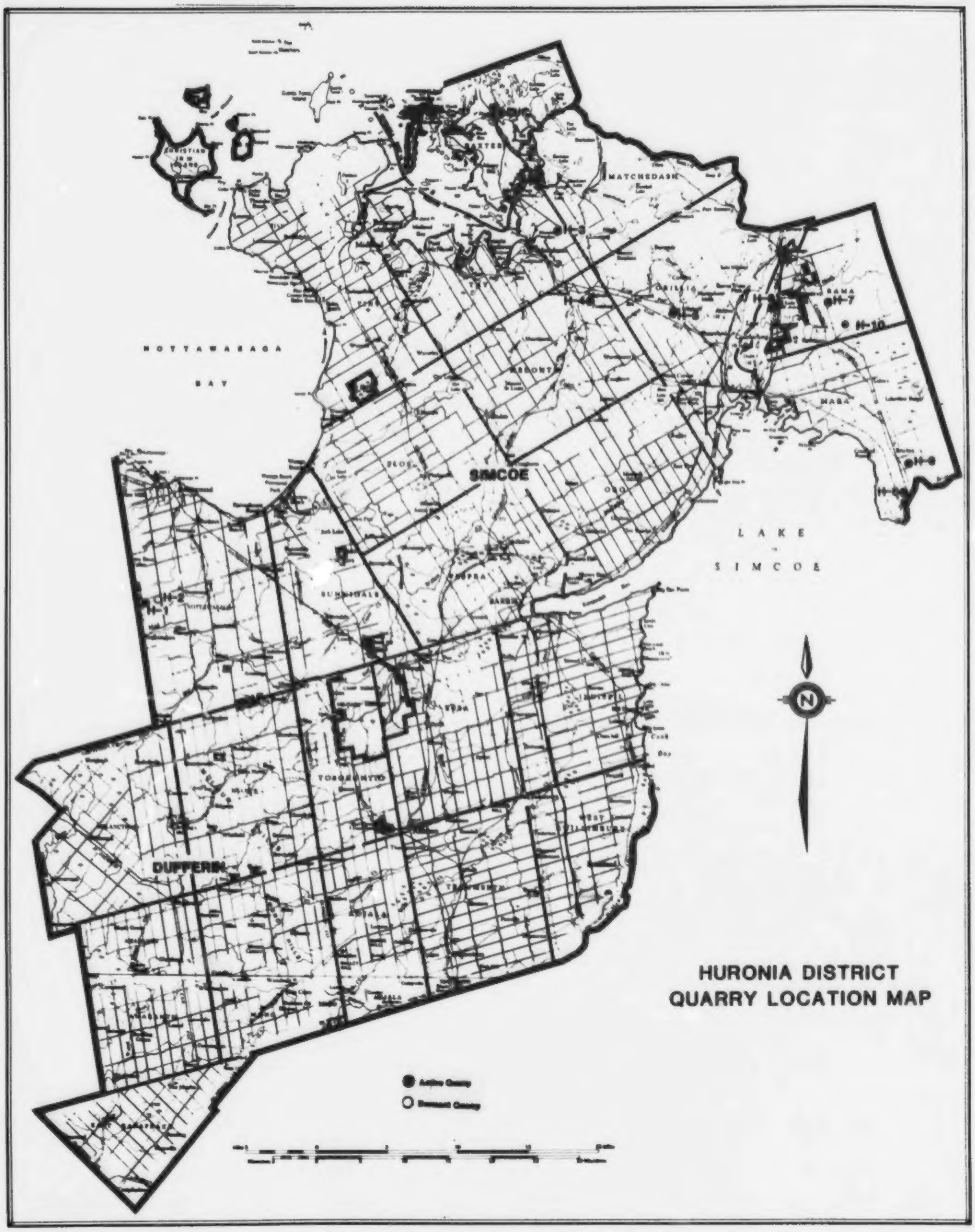
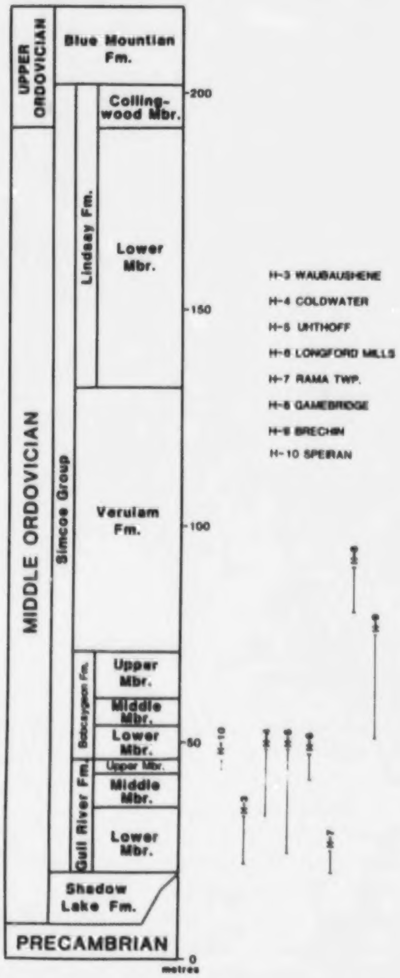

MATCHEDASH
ORILLIA
RAMA
H-7
H-10
NOTTAWASAGA BAY
MARA
ORO
SIMCOE
LAKE SIMCOE
SUNNIDALE
H-2
H-1
N
TOSSORONTIO
WEST GWILLIMBURY
DUFFERIN
HURONIA DISTRICT
QUARRY LOCATION MAP

Figure H-0-1. HURONIA DISTRICT QUARRY LOCATION MAP.



N.B.: H-1 & H-2 are illustrated on the Cambridge District chart

Maximum thicknesses are assumed for this section

Figure H-0-2. STRATIGRAPHIC COLUMN SHOWING PRINCIPAL QUARRIES OF HURONIA DISTRICT.

(H–4), Uhthoff (H–5), and Woods (H–6) quarries, which are all worked for crushed stone. South of the Woods Quarry are a string of abandoned, building stone quarries which were known for "Rama" stone and the "Longford" stone. The "Rama" stone is a buff dolostone of the lower member, Gull River Formation and the "Longford" stone is a white, high calcium, microcrystalline limestone which has a smooth lithographic texture, of the middle member, Gull River Formation.

The Bobcaygeon Formation overlies the Gull River Formation with a prominent contact (Liberty, 1969b) in the Huronia District. The lower contact of the Bobcaygeon Formation occurs where grey, fine– to coarse–crystalline, very fossiliferous limestone overlies the uppermost microcrystalline limestone of the Gull River Formation. This contact can be observed in the Medonte (H–4) and Uhthoff (H–5) quarries.

The Bobcaygeon Formation has been subdivided into the lower, middle and upper members (Liberty, 1969b). The lower member consists of 8 m of grey, fine– to coarse–crystalline, fossiliferous limestone and coarse–grained calcarenites. The middle member consists of about 6 m of grey and brown, microcrystalline to very fine–crystalline, sparsely fossiliferous limestone. The upper member consists of about 11 m of grey to bluish grey, fine– to medium–crystalline limestone alternating with coarse–grained calcarenites which have a granular appearance. The Brechin Quarry (H–9) exposes the most complete section of the Bobcaygeon Formation in this district.

The Verulam Formation which overlies the Bobcaygeon Formation was previously subdivided into upper and lower members by Liberty (1969b), but in this report no subdivisions have been made. The strata of the formation consist of interbedded grey, fossiliferous, thin–bedded limestone and dark grey shale. The Verulam Formation is exposed in the Gamebridge Quarry (H–8) and the upper portion of the Brechin Quarry (H–9).

Overlying the Verulam Formation are thin–bedded, nodular limestones of the Lindsay Formation, which is about 60 m thick. The Collingwood Member, a black calcareous shale (Russell and Telford, 1983), is exposed around Collingwood and forms the upper part of the Lindsay Formation. There are no quarries presently utilizing the limestones of the Lindsay Formation in the Huronia District, although there are some old abandoned quarries in the Collingwood area.

The limestones of the Simcoe Group are overlain by blue–grey shales of the Upper Ordovician Blue Mountain Formation (Russell and Telford, 1983), which are exposed near Collingwood. The shales are not quarried in the Huronia District.

The shales of the Blue Mountain Formation are overlain by the interbedded limestone and shale of the Georgian Bay Formation. In the Huronia District these strata occur underneath thick glacial overburden in the southwestern part of the district.

The red shales of the Upper Ordovician Queenston Formation, which overlie the Georgian Bay Formation, form the base of the Niagara Escarpment. These red shales are quarried in many localities along the escarpment, mainly as a raw material for the brick and ceramic industry.

The Silurian strata, which form the Niagara Escarpment in the western part of the district, are described in the discussion on the Cambridge and Owen Sound districts in which the Escarpment also occurs. In the Huronia District there is only one quarry presently operating in the Silurian rocks. This is the McKean–

Duntroon Quarry (H–1) which exposes up to 12 m of the Amabel Formation. The Amabel Formation in this quarry is a massive, irregular-bedded, fine- to coarse-crystalline, biohermal dolostone. An abandoned quarry (H–2), just east of the McKean–Duntroon Quarry, exposes the Queenston, Whirlpool and Manitoulin Formations.

## LIMESTONE INDUSTRIES

The principal limestone industry in Huronia District is limestone aggregate production, from armour stone down to agricultural lime and screenings. Small amounts of building stone are produced from the Speiran Quarry (H–10).

Stone production is restricted to Simcoe County and totalled approximately 4,626,000 tonnes in 1986 (1987 Ontario Mineral Score). Of this total, over two–thirds was produced from the Uhthoff Quarry (H–5) and the Brechin Quarry (H–9). The aggregates produced were used for road, construction and asphalt aggregate.

## H–1 McKEAN QUARRIES LIMITED — DUNTROON QUARRY

### LOCATION AND OWNERSHIP

The Duntroon Quarry is located approximately 4 km west of Duntroon in Lot 24, Concession 12, Nottawasaga Township (Figure H–1–1), and is owned and operated by McKean Quarries Limited which is a division of Seeley and Arnill Construction Ltd. The licensed area of the quarry is 49.81 ha. The quarry has been in operation since 1963 and now includes a large asphalt plant also operated by McKean Quarries Limited.

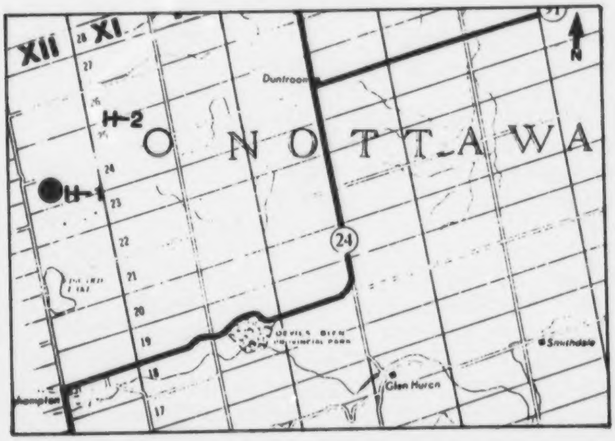


Figure H–1–1. LOCATION MAP FOR DUNTROON QUARRY.

### GEOLOGY

This quarry is one of the few quarries opened on the Niagara Escarpment in the Collingwood–Nottawasaga area. This quarry exposes 7 m to 12 m of the Amabel Formation, here a biohermal dolostone. The vertical face is very irregular because of its massive biohermal nature and the related flank beds which are more evenly bedded and rubbly. Overburden averages 1 m and is used in reclamation of worked–out quarry areas.

### Geological Section

*Thickness*

*UNIT 1 Amabel Formation* *7-12m*

Biohermal dolostone: blue–grey to cream, with pink and green colouring in places, weathers buff with rust staining; fine to coarse crystalline; thick to massive bedded with flanks of bioherms medium bedded, contacts are very irregular and undulating; scattered pink coloured dolomite crystals; very vuggy and porous appearance; some bituminous partings present at the base; mottled appearance; fossils present include abundant crinoids (in lenses), stromatoporoids (more abundant at top and cone–shaped: up to 5 x 20 cm), corals and rare nautiloids and brachiopods, some bioturbation; rare silicification of fossils.

### QUARRY OPERATION

The quarry currently operates from the middle of March through to the middle of December; product shipping operates on a year round basis.

The quarry is currently producing from a single lift exposing an average 10 m working face. The rock is drilled with rotary drills and blasted with AN/FO using high explosives in the bottom of the holes. The broken rock is excavated and delivered to the primary crusher by a front end loader.

### PROCESSING

A single impeller Cedarapids 5248 impact crusher equipped with a vibrating grizzly reduces the quarry run to approximately –8 in. This material is delivered to the stockpile area by a conveyor belt and radial stacking conveyor. The stockpile is recovered through a "below ground" draw point and conveyed to a primary screening tower where the material is passed over two double–deck 3 ft. x 16 ft. primary screens. The screen oversize is Granular "A" and is stockpiled by a stacking conveyor. Depending on the screen selection a –2 in. + 7/8 in. Group 4 clear aggregate can also be produced in addition to the Granular "A" material. It is also possible by screen selection and blending to produce a 2 in. crusher run or 3/8 in. C–gravel. Products are conveyed to a radial luffing stacking conveyor for stockpiling. The screen oversize is conveyed to the secondary screening and crushing plant where the material is passed over a double–deck vibrating screen in closed circuit with a Pulvamatic impact crusher. Depending on the screen selection, 3/4 in. clear stone and 1/4 in. screenings, 2 in. clear stone and 1/4 in. screenings or –7/8 in. +1/4 in.

clear stone and 1/4 in. screenings can be produced. The 1/4 in. screenings can be separated on an additional screen into −1/4 in. +8 mesh asphalt sand and −8 mesh agricultural lime. The −7/8 in. +1/4 in. clear stone can be separated on a washing screen into −3/4 in. clear concrete stone, −5/8 in. +1/4 in. washed HL4 and −7/8 in. +5/8 in. or −1/2 in. +1/4 in. HL3. These products are stockpiled or stored in individual bins.

The stone products used in the asphalt plant, a Barber–Greene 6500 lb. batch unit, are transported by truck to separate stockpiles next to the plant.

Armour stone can be produced by selecting suitable blocks from shot rock in weights of up to 8 tons.

Other specialty products are riprap and gabion stone. Coarse stone is selected from shot rock by front end loader and hauled to a special 5 ft. x 16 ft. Assinck Bros. two step grizzly screen with adjustable spacer bars. Riprap is made in the following size ranges: 10 in. x 30 in., 8 in. x 24 in. and 6 in. x 12 in. Gabion stone is produced in 6 in. x 8 in. and 4 in. x 6 in. sizes. Undersize from the grizzly screen is −4 in. and is diverted to the discharge belt of the primary impact crusher.

### PRODUCTS

Armour Stone
Riprap 10 in. x 30 in., 8 in. x 24 in., and 6 in. x 12 in.
Gabion Stone 4 in. x 6 in. and 6 in. x 8 in.
2 in. Crusher Run
Granular "A"
−2 in. + 7/8 in. Group 4 Clear
2 in. Clear Stone
3/4 in. Clear Stone
−7/8 in. + 1/4 in. Clear Stone
3/8 in. C–Gravel
HL4
HL3
1/4 in. Screenings
Asphalt Sand
Agricultural Lime

### REFERENCES

Hewitt, 1964a, p. 57–58
Vos, 1969, p.59
Hewitt and Vos, 1972, p. 53

### MAPS

Telford, 1976a, ODM Map 2341

## H–2 DUNTROON QUARRY

### LOCATION AND OWNERSHIP

This small abandoned quarry is located 2.5 km west of Duntroon on the edge of the Niagara Escarpment in Lot 24 ($E^1/_2$), Concession 11, Nottawasaga Township, Simcoe County (Figure H–2–1).

### GEOLOGY

The quarry is geologically significant because it exposes 10.3 m of the Queenston, Whirlpool and Manitoulin Formations. Below the quarry floor, the red calcareous shales of the Queenston Formation are exposed and are overlain by calcareous sandstones of the Whirlpool Formation (3 to 4 m). The Whirlpool Formation is in turn overlain by 6.3 m of the Manitoulin Formation, a calcareous dolostone.

#### Geological Section

*Thickness*

*UNIT 2 Manitoulin Formation* *6.3m*

Calcareous dolostone: grey to medium grey, weathers buff; subcrystalline to very fine crystalline; thin to medium bedded (5 to 10 cm), contacts are sharp and slightly irregular; white chert nodules are present in the upper 1.5 m and are usually about 3 cm in diameter; calcite present in vugs; some stylolites; mottled appearance; rare brachiopods; lower 0.5 m consists of interbedded shales, sandstones and dolostones; the lower contact is sharp.

*UNIT 1 Whirlpool Formation* *4.0m*

Calcareous sandstone: green–grey, weathers grey; fine grained; thin to medium bedded; unit is very poorly exposed; some rip–up clasts at the top of the unit; rib and furrow structure can be seen on bedding planes; lower contact is obscured by rubble, although the Queenston Formation shale is exposed in an adjacent outcrop below the quarry floor.

*Total thickness* *10.3m*

### REFERENCES

Vos, 1969, p. 59

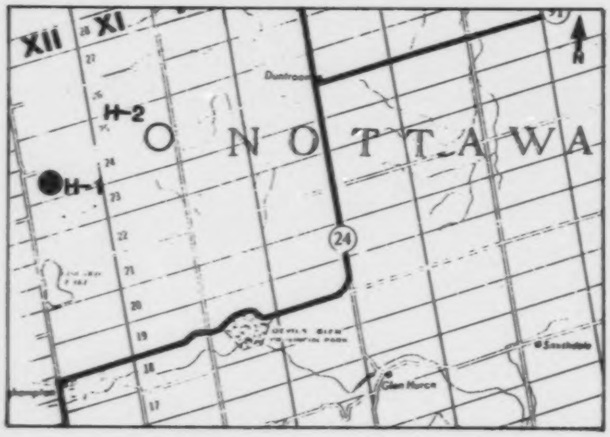


Figure H–2–1. LOCATION MAP FOR DUNTROON QUARRY.

## MAPS

Telford, 1976a, ODM Map 2341

## H-3 ALLAN G. COOK LTD. — COLDWATER (WAUBAUSHENE) QUARRY

### LOCATION AND OWNERSHIP

The Coldwater Quarry is located 7 km north of the Village of Coldwater, in Lots 8, 9, 10 and part of Lot 11, Concession 14, Tay Township, Simcoe County (Figure H-3-1). The quarry was opened in 1968 by the present owner and operator Allan G. Cook Ltd., and is licensed for a total of 270.0 ha.

The quarry supplies aggregate products in a region generally defined by the cities of Barrie and Orillia and the towns of Parry Sound and Midland. The Coldwater Quarry has supplied a considerable quantity of aggregate products for construction and maintenance of Highways 400 and 69 and locally supplies limestone for township roads, tile filter beds and shoreline protection.

The quarry normally operates during the period April to mid-December. Approximately one-quarter of the quarry production is used by A. G. Cook Ltd. to supply their construction projects and asphalt plant.

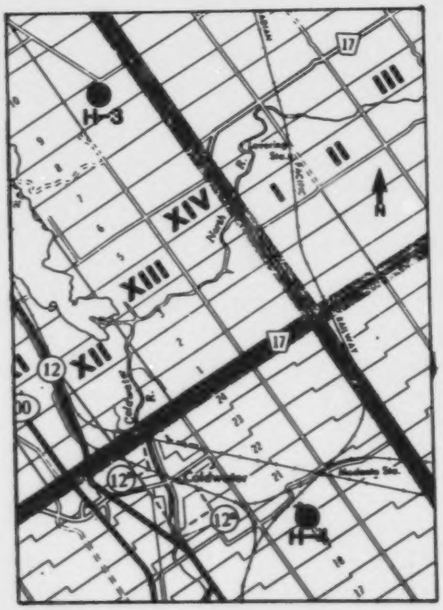


Figure H-3-1. LOCATION MAP FOR COLDWATER (WAUBAUSHENE) QUARRY.

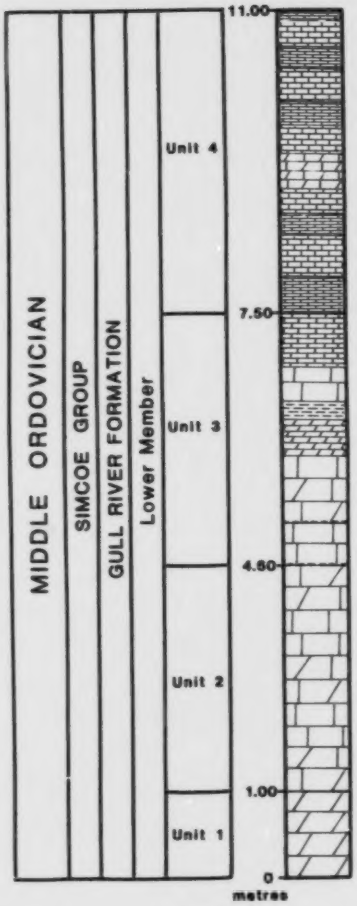


Figure H-3-2. STRATIGRAPHIC COLUMN FOR COLDWATER (WAUBAUSHENE) QUARRY.

### GEOLOGY

The quarry is located in a Paleozoic outlier of the Gull River Formation on the Precambrian rocks and exposes 11.0 m of the lower member of the Gull River Formation (Figure H-3-2). A water-filled sump reveals that strata below the main quarry floor consist of silty and sandy dolostone. The underlying Shadow Lake Formation occurs just below the exposed section in the quarry (based on drill hole logs in Koniuszy and Rogers, 1983). The lower part of the face exposes 5.1 m of interbedded limestone, dolomitic limestone and dolostone, capped by a 30 cm thick interval of light green dolostone which includes 8 cm of soft green shale. The upper 4.9 m consists of interbedded dolomitic limestone and limestone, commonly with light green glauconite present as a coating on fossils or on bedding planes. Glacial overburden is less than 0.5 m thick around the quarry.

### Geological Section

*Thickness*

*UNIT 4 Gull River Formation, lower member* *3.5m*

Limestone: mottled light grey and medium grey-brown, weathers same; microcrystalline with a lithographic texture; thin to medium bedded (5-10 cm, rarely 30 cm) with sharp, irregular contacts; green coatings on some fossils; abundant burrows, some are lighter grey due to dolomitization; lower contact is sharp, irregular.

*UNIT 3 Gull River Formation, lower member* *2.9m*

Limestone and dolomitic limestone:light brown to light grey; weathers same; microcrystalline to very fine crystalline; medium to thick bedded (15-50 cm), with beds thicker at base of unit and thinning upwards; sharp contacts, some irregular with very thin shale partings; at 1.2m above base of unit is a 30 cm thick, thin-laminated, very soft, recessive green dolostone; near top of unit are two intraformational conglomerates, 10 cm thick, with clasts up to 5 cm in diameter of microcrystalline limestone and rare bioclasts; rare brachiopods near top of unit; lower contact of unit sharp and irregular; top of lower lift 1.5 m above base of unit at top of green dolostone.

*UNIT 2 Gull River Formation, lower member* *3.6m*

Interbedded limestone and dolomitic limestone: light brown to medium grey, weathers light brown to light grey; limestone microcrystalline to very fine crystalline, with a lithographic texture; dolomitic limestone very fine crystalline, with some terrigenous material, from mud to sand sized; medium to thick bedded (20-40 cm); dolomitic limestone is thin-laminated in some beds; sharp contacts, some with very thin, light green shale partings; patches of calcite crystals common in dolomitic limestone; small, disseminated and euhedral pyrite crystals; lower contact of unit sharp and planar, possibly erosional, marked in places by euhedral pyrite crystals up to 5 mm in diameter.

*UNIT 1 Gull River Formation, lower member* *1.0m*

Dolostone: light green to grey, weathers light green; very fine crystalline with silt to very fine-grained sand; thick bedded (40-50 cm), beds contain stylolites which weather into thin, platy fragments; sharp, planar contacts; small pyrite crystals scattered through most beds; top of unit at floor of quarry, this unit above water level in sump.

*Total thickness* *11.0m*

### QUARRY OPERATION

The quarry has a disturbed area of about 40 ha and is excavated in four lifts to a total depth of about 11.0 m. The first lift of 4.9 m is used to supply asphalt and concrete stone products and is mined down to the green shale layer known as the "green marker". The second lift (0.6 m) is used to produce crusher run stone and includes approximately 0.15 m of the green shale marker, 0.15 m shale transition stone, and about 0.3 m of dolomitic limestone. The third lift of 3.0 m is used to produce asphalt and concrete stone products. The fourth (bottom) lift of 1.8 m is used to produce crusher run material.

A drill pattern of 2.7 m x 2.7 m is used with a 7.6 cm diameter blast hole on the 1st, 3rd and 4th lifts. On the short second lift (0.6 m) a drill pattern of about 2.1 m x 2.1 m with 7.6 cm diameter blast holes is used; holes are loaded with a single cartridge of Tovex 2000 and initiated with an electric cap.

### PROCESSING

A 5 1/2 yd. Volvo 4600 is used to load two 35-ton Haulpak trucks for haulage to the 36 in. x 42 in. Cedarapids double impeller primary crusher. The crushed rock is sent to a surge pile and fed by a 36 in. vibrating feeder to the tunnel conveyor and one 5 ft. x 12 ft. screen and one 1 ft. x 4 ft. screen producing gabion stone, 1 in. crusher run and intermediate material that is recrushed in two 48S Telsmith cone crushers. Stone leaving the cone crushers is then sent to a 5 ft. x 12 ft. double-deck Tyrock 900 screen producing +3 1/2 in. oversize, 2 in. clear and −1 3/4 in. stone. The −1 3/4 in. product is sent to an 8 ft. x 20 ft. Simplicity screen producing +1 1/2 in. and −3/4 in. clear stone; the −3/4 stone is sent to an 8 ft. x 20 ft. Simplicity screen producing HL4, HL3 and HL6 as required. The −5/16 is sent to a screening pile for stockpile. All oversize and products not required are sent to the Pulvamatic crusher. All stone is stockpiled by radial stacking conveyors.

### PRODUCTS

Armour Stone
Gabion Stone
4 in. x 6 in.
6 in. x 12 in.
2 in. Crusher Run
1 1/2 in. Crusher Run
7/8 in. Crusher Run
5/8 in. Crusher Run
2 in. Clear Stone
1 in. Clear Stone
3/4 in. Clear Stone
HL6
HL4
HL3
3/8 in. Chips

### REFERENCES

Hewitt and Vos, 1972, p.18-19

Koniuszy and Rogers, 1983

### MAPS

None

## H-4 MINISTRY OF TRANSPORTATION — MEDONTE (COLDWATER) QUARRY

### LOCATION AND OWNERSHIP

The Medonte Quarry is located 2 km east of Coldwater in Lots 19 and 20, Concession 13, Medonte Township, Simcoe County (Figure H-4-1). The quarry is used intermittently by the Ministry of Transportation as a source for crushed stone. The quarry was previously operated by Coldwater Crushed Stone Ltd. and Limestone Products Ltd.

### GEOLOGY

The 14.15 m deep quarry exposes limestones and dolostones of the lower, middle and upper members of the Gull River Formation, and the lower member, Bobcaygeon Formation (as defined by Liberty, 1969b), in a single lift (Figure H-4-2). There are 3 to 4 m of glacial overburden at the top of the quarry, which has been excavated into a hillside.

The lower member of the Gull River Formation is exposed below the main quarry floor in a 2 m deep drainage ditch at the quarry's east end. The exposed strata consist mainly of dolostone. The upper contact of the member is marked by a 10 cm thick soft, recessive, plastic clay which weathers green.

The microcrystalline limestones of the middle member displays various hues of grey, including two intervals that weather white. The beds commonly have a lithographic texture with well developed "birdseye" textures and are commonly disrupted by numerous stylolites. The upper contact of the member is marked by a 10 cm thick recessive shale bed which weathers into a plastic clay.

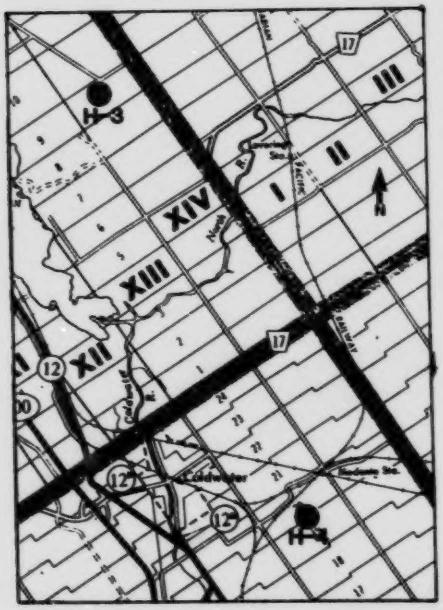

H-3
H-4
XIV
XIII
XII
III
II
I
17
12
N
Coldwater

Figure H-4-1. LOCATION MAP FOR MEDONTE (COLDWATER) QUARRY.

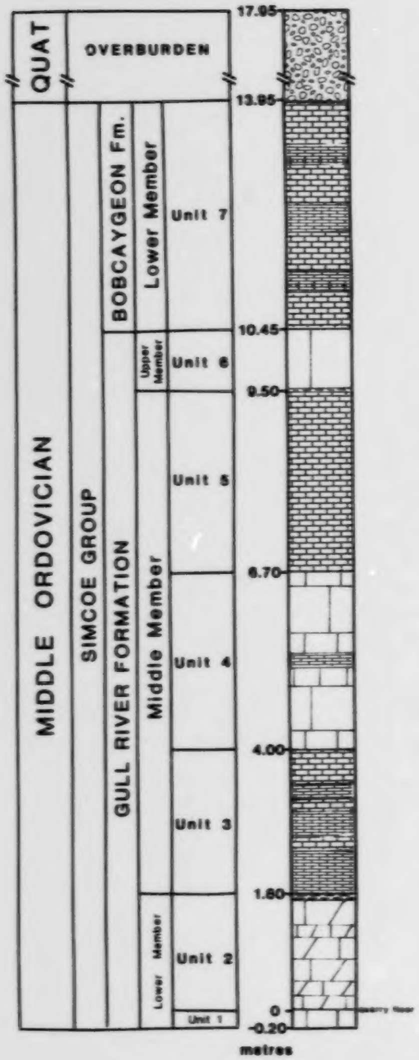

QUAT
OVERBURDEN
MIDDLE ORDOVICIAN
SIMCOE GROUP
BOBCAYGEON Fm.
Lower Member
GULL RIVER FORMATION
Upper Member
Middle Member
Lower Member
Unit 7
Unit 6
Unit 5
Unit 4
Unit 3
Unit 2
Unit 1
17.95
13.85
10.45
9.50
6.70
4.00
1.80
0
-0.20
metres
quarry floor

Figure H-4-2. STRATIGRAPHIC COLUMN FOR MEDONTE (COLDWATER) QUARRY.

The upper member is only 1 m thick in this quarry and consists of microcrystalline limestone. White and black chert occur in the member as nodules and discontinuous beds. The upper contact of the Gull River Formation is sharp and irregular in some parts of the quarry, but in other parts it appears to be transitional with the overlying strata.

The 3.5 m thick lower member of the Bobcaygeon Formation typically contains medium- to coarse-grained calcarenites interbedded with fine- to medium-crystalline bioclastic limestones. Some of the calcarenites display small-scale crossbedding.

### Geological Section

*Thickness*

*UNIT 7 Bobcaygeon Formation, lower member* *3.5m*

Limestone: light to medium grey, weathers medium to dark grey, with a rubbly and pitted appearance; fine to medium crystalline, with some medium- to coarse-grained calcarenites; thin to medium bedded (5-20 cm) with sharp, slightly irregular, stylolitic contacts or with rare, thin, discontinuous shale partings; very fossiliferous and bioclastic; lower contact of unit sharp and irregular in places, transitional in others.

*UNIT 6 Gull River Formation, upper member* *0.95m*

Limestone: light grey, weathers medium grey; microcrystalline, with a lithographic texture; single bed; white and black chert in irregular patches and discontinuous beds 60 to 70 cm above base of unit; rare brachiopods near top; lower contact of unit sharp at a 10 cm recessive shale bed which weathers into a plastic clay.

*UNIT 5 Gull River Formation, middle member* *2.8m*

Limestone: light grey, weathers light to medium grey; microcrystalline with a lithographic texture; medium bedded (20-25 cm); sharp, planar contacts; stylolites common throughout beds; some intraformational conglomerates with clasts up to 3 mm in diameter, glauconite and hematite coatings on some clasts; small patches of calcite crystals ("birdseye" texture) present; rare, small pyrite crystals; lower contact sharp and planar.

*UNIT 4 Gull River Formation, middle member* *2.7m*

Limestone: very light grey to cream, weathers very light grey to white; microcrystalline with a lithographic texture; thick bedded (30-60 cm) with sharp, rarely stylolitic contacts; stylolites are common throughout beds and increase in abundance upwards; intraformational conglomerates with subrounded, disc-like clasts, some with original laminations; interbeds of thin-bedded, white microcrystalline limestone, commonly containing vertical calcite-filled burrows (*Skolithos*); small patches of calcite crystals ("birdseye" texture) present; rare, small pyrite crystals; lower contact of unit sharp and planar.

*UNIT 3 Gull River Formation, middle member* *2.2m*

Limestone: light brown, weathers dark to medium grey; microcrystalline with a lithographic texture; thin to medium bedded (5-20 cm) with thicker (30-50 cm) beds towards top of unit; sharp, planar contacts, some stylolitic with very thin, light green shale partings; small patches of calcite crystals ("birdseye" texture) present and thin calcite-filled veins trending northeast; lower contact of unit sharp and planar, at top of green silty dolostone bed at base of very soft, recessive clay bed; main quarry floor at 0.4 m above base of unit.

*UNIT 2 Gull River Formation, lower member* *1.8m*

Dolostone: light grey-green, weathers buff to grey-green; very fine crystalline with some terrigenous silt; medium to thick bedded (10-50 cm) with sharp and planar contacts; unit includes beds which vary from thin bedded and recessive to thick bedded and conchoidally fractured; lower contact of unit sharp.

*UNIT 1 Gull River Formation, lower member* *0.2m*

Limestone: light brown, weathers medium grey; microcrystalline with a lithographic texture; one bed 20 cm thick; rare patches of calcite crystals; scattered chert nodules; units 1 and 2 occur below main quarry floor in drainage ditch and very old section of quarry.

*Total thickness* *14.15m*

### REFERENCES

Liberty, 1953b, p.3

Hewitt, 1960, p.29-31

Liberty, 1969b, pp.3, 22-31, 98, 124

### MAPS

Liberty, 1953a, GSC Map 53-16

Liberty, 1969a, GSC Map 1228A

## H-5 NELSON AGGREGATE COMPANY – UHTHOFF QUARRY

### LOCATION AND OWNERSHIP

This very large quarry is located 10 km northwest of Orillia, near the hamlet of Uhthoff in Lots 7, 8, 9, and 10, Concessions 3, 4, and 5 N.D., Orillia Township, Simcoe County (Figure H-5-1).

The quarry is owned and operated by Nelson Aggregate Company and has a nominal annual capacity of 2,000,000 tonnes. The quarry is served by Canadian Pa-

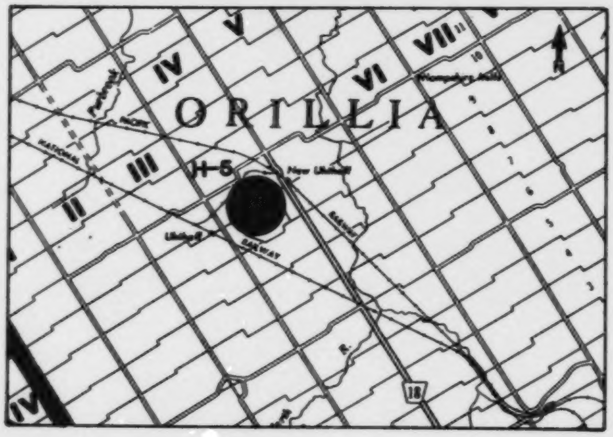


**Figure H-5-1. LOCATION MAP FOR UHTHOFF QUARRY.**

cific and Canadian National rail lines, and by truck haulage. The quarry licence covers an area of 362.68 ha.

## GEOLOGY

The 24.5 m deep quarry exposes an excellent section of the lower, middle and upper members of the Gull River Formation and the lower member of the Bobcaygeon Formation (Figure H-5-2), as defined by Liberty (1969b). Three lifts have been excavated.

In the quarry the lower member, Gull River Formation, consists of 10.4 m of very fine- to medium-crystalline interbedded dolostone and limestone. The 7.45 m thick middle member consists of microcrystalline, light grey to cream limestone which exhibits a lithographic texture. The upper member consists of 2.3 m of light to medium grey, microcrystalline limestone.

The contact between the Gull River and Bobcaygeon Formations is placed at the lowest occurrence of coarse-grained calcarenites and is transitional over approximately 1 m. The lower member of the Bobcaygeon Formation, as defined by Liberty (1969b), is a light grey, medium- to coarse-crystalline, very fossiliferous limestone. There are 2.3 m of Bobcaygeon Formation overlying a total of 22.25 m of Gull River formation in this quarry. The glacial overburden around the quarry is up to 4 m thick.

### Geological Section

| | *Thickness* |
|---|---|
| *UNIT 9 Bobcaygeon Formation, lower member* | *2.3m* |

**Limestone: light to medium grey, weathers same; medium- to coarse-grained calcarenites; medium to thick bedded (20-40 cm) with stylolitic contacts; lower portion of unit consists of alternating microcrystalline and coarse-crystalline limestone, may be transitional to upper Gull River Formation, 1 m above base of unit is a 3 cm thick, very soft, recessive bed of plastic clay; rare, small patches of calcite crystals; fossiliferous, with corals, stromatoporoids, and brachiopods most common, burrows also abundant; lower contact of unit sharp and irregular, appears erosional in places.**

| | |
|---|---|
| *UNIT 8 Gull River Formation, upper member* | *2.3m* |

**Limestone: light to medium grey, weathers same; microcrystalline; medium bedded (10-30 cm), stylolitic contacts, some with thin dark grey, shaly limestone partings; small patches of calcite crystals ("birdseye" texture) present; fossiliferous, with abundant corals (*Tetradium*), fossil fragments and burrows; lower contact of unit sharp and planar.**

| | |
|---|---|
| *UNIT 7 Gull River Formation, middle member* | *2.6m* |

**Limestone: light to medium brown, mottled dark grey, some beds white to cream, weathers same; microcrystalline, with a lithographic texture; medium bedded (15-30 cm) with sharp, planar and stylolitic contacts, rare interbeds of thin-bedded (2-5 cm), recessive shaly limestone; upper 1 m is a distinctively white to cream, medium- bedded microcrystalline limestone with a lithographic texture which contains abundant burrows; small patches of calcite crystals ("birdseye" texture) present; rare, small pyrite crystals; sparsely fossiliferous with ostracods present**

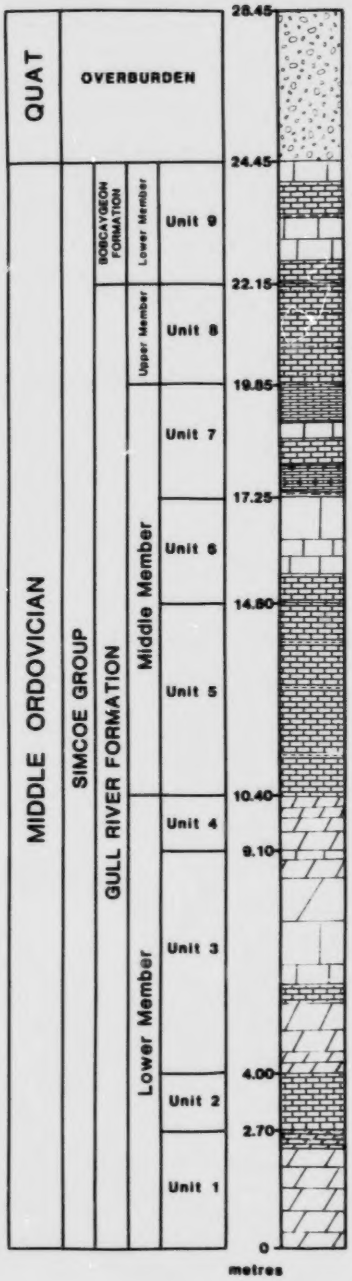


**Figure H-5-2. STRATIGRAPHIC COLUMN FOR UHTHOFF QUARRY.**

0.7–1.6 m above base of unit; lower contact of unit sharp at a 2 mm shale bed.

*UNIT 6 Gull River Formation, middle member 2.45m*

Limestone: light brown, upper 75 cm white, weathers same; microcrystalline with a lithographic texture; medium to thick bedded (15–75 cm), stylolitic contacts; upper 0.75 m is a distinctive white, microcrystalline limestone with a lithographic texture which contains abundant stylolites; small patches of calcite crystals ("birdseye" texture) present; rare small pyrite crystals; abundant small black, irregular shaped patches which appear to be burrows coated with bitumen; lower contact of unit sharp and planar, at top of 2nd lift.

*UNIT 5 Gull River Formation, middle member 4.4m*

Limestone: light to medium brown and grey, weathers same; microcrystalline, with a lithographic texture; medium bedded (15–20 cm), sharp, planar or stylolitic contacts, some with thin shale partings; stylolites abundant throughout some beds; 3.2 m above base of unit intraformational conglomerates with light grey, microcrystalline clasts common; 0.5 m above base of unit 30 cm thick light green, laminated, silty dolostone; small patches of calcite crystals ("birdseye" texture) present; fossiliferous, brachiopods most abundant and some burrows on bedding planes; lower contact of unit sharp, at top of lower lift.

*UNIT 4 Gull River Formation, lower member 1.3m*

Dolostone: medium grey-brown to light green, weathers light to medium brown, upper 40 cm light green; fine to medium crystalline; medium bedded (20–30 cm), sharp and planar contacts; abundant burrows on bedding planes; lower contact sharp and irregular, to stylolitic.

*UNIT 3 Gull River Formation, lower member 5.1m*

Interbedded limestone and dolostone: mottled grey and brown, weathers same; limestone microcrystalline, dolostone fine to medium crystalline; medium to thick bedded (10–60 cm), sharp, irregular, stylolitic contacts; small patches of calcite crystals ("birdseye" texture) present; glauconite coating fossils and bedding planes; interval with abundant white chert as nodules and discontinuous beds 4.0 m above base of unit; fossiliferous in limestones, abundant brachiopods, cephalopods, bivalves, and burrows on bedding planes; lower contact of unit sharp at main quarry floor.

*UNIT 2 Gull River Formation, lower member 1.3m*

Limestone: light grey, weathers same; microcrystalline to very fine crystalline; medium bedded (10–20 cm), sharp, slightly irregular contacts; intraformational conglomerate 40 cm above base of unit with light to dark grey clasts of microcrystalline limestone and patches of calcite crystals; rare small pyrite crystals; sparsely fossiliferous with ostracod fragments and abundant burrows; lower contact of unit sharp and irregular.

*UNIT 1 Gull River Formation, lower member 2.7m*

Dolostone: light grey, weathers light green-grey; very fine to fine crystalline, upper 40 cm contains medium- to coarse-grained, well rounded, quartz sand grains; medium to thick bedded (30–50 cm), sharp, planar to undulatory contacts: small pyrite crystals in lowest 30 cm; small, open vugs common; sparsely fossiliferous; Units 1 and 2 exposed above water level in sump.

*Total thickness 20.45m*

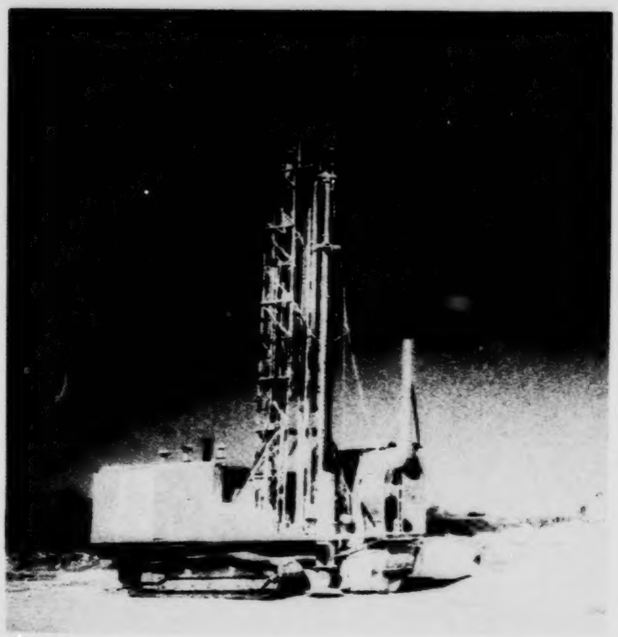


Photo H-5-1. BUCYRUS-ERIE 40R ROTARY DIESEL DRILL AT THE UHTHOFF QUARRY.

## QUARRY OPERATION

The Uhthoff quarry is one of the largest quarries in the Province of Ontario; over 35,000,000 tonnes of aggregate material have been extracted since the quarry was opened.

The quarry is worked on three lifts of 9.7 m, 4.4 m and 6.4 m. Stone extracted from the upper and lower lifts is used to produce asphalt and concrete stone products; the middle lift is used to produce granular products.

Drilling is performed by a Bucyrus–Erie 40R Rotary diesel drill, using a 171 mm bit on a 5.5 m x 5.5 m pattern. Large diameter water gel explosives are used at the toe of the hole with AN/FO as column load. The blasted stone is loaded by two Cat 988B loaders into three 40–ton Terex 3307 and four 35–ton Euclid 201 haulage trucks. The haulage distance from the quarry face to primary crushing is about 1,500 m.

## PROCESSING

The process flow sheet is shown on Figure H–5–3. The blasted stone is dumped into either a 36 in. Allis–Chalmers gyratory crusher, feeding a −10 in. surge pile or a 40 in. x 48 in. Buchanan jaw crusher, feeding a −12 in. 60 tonne surge tank. Material from the surge tank is conveyed to the Crusher Run plant and a Tyler 800 double-deck screen, producing either −12 in. + 6 in. and −6 in. + 4 in. gabion stone, or routing that coarse material

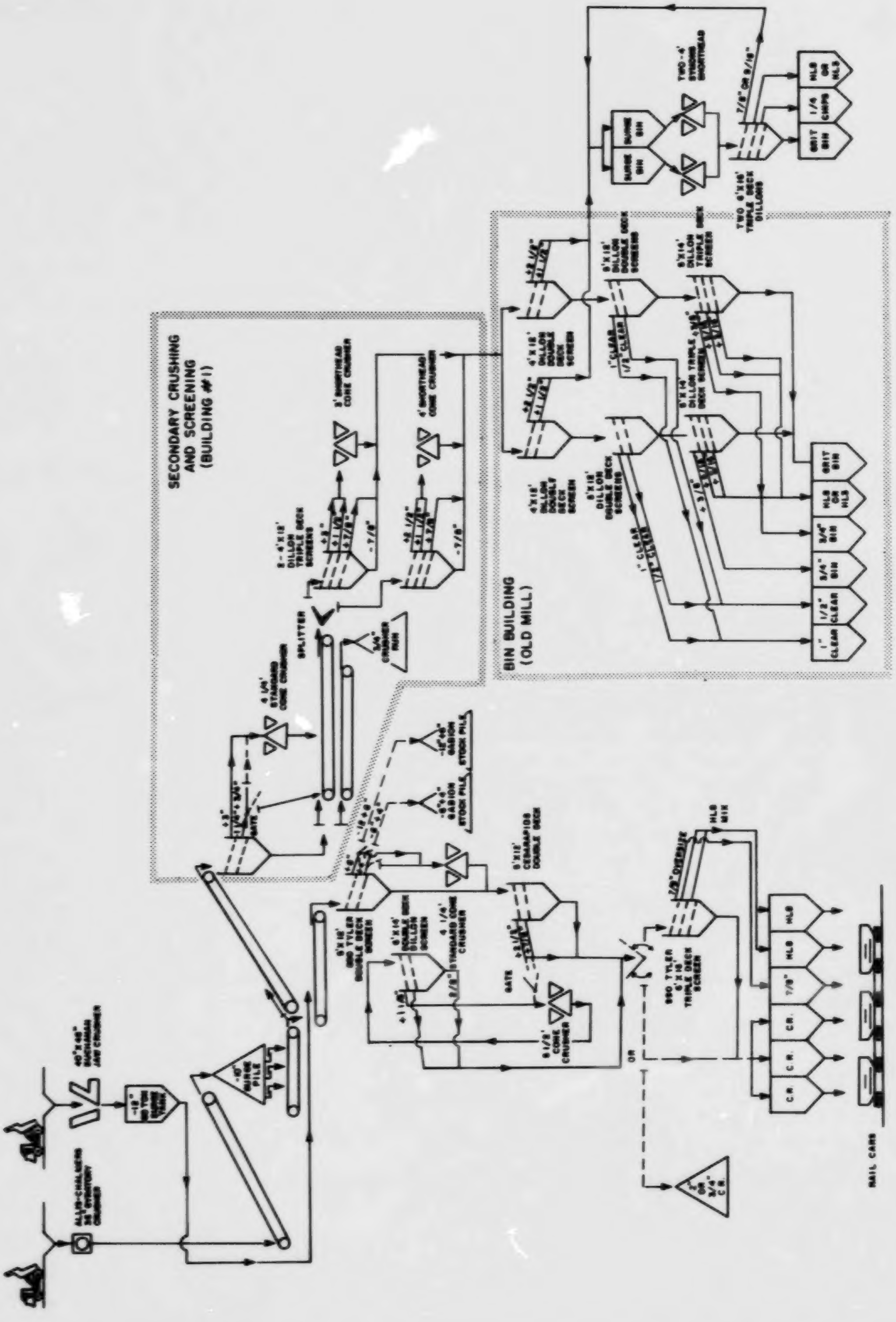
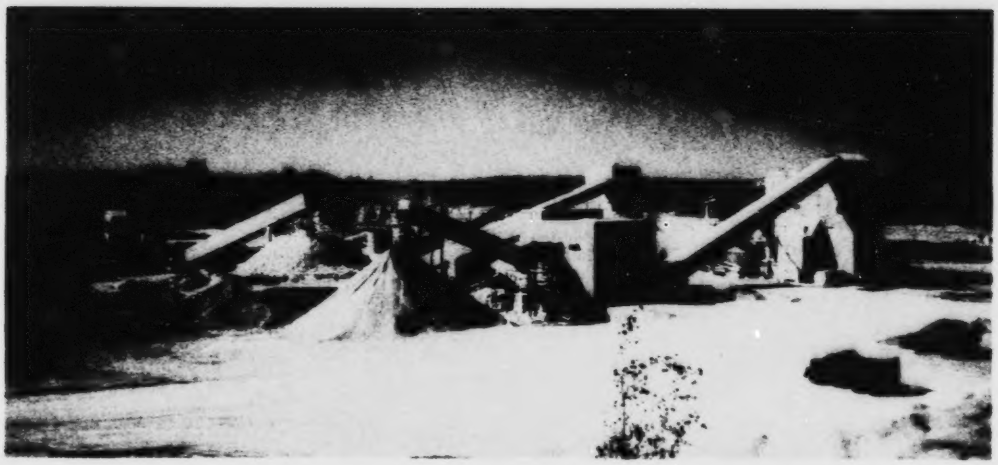

SECONDARY CRUSHING AND SCREENING (BUILDING #1)
BIN BUILDING (OLD MILL)
SPLITTER
1" CLEAR
1/2" CLEAR
3/4" BIN
GRIT BIN
HL6 OR HL3
C.R.
7/8"
HL6
HL6 MIX
RAIL CARS
GATE
OR

Figure H-5-3. PROCESS FLOW CHART FOR UHTHOFF QUARRY.

**Photo H-5-2. UHTHOFF QUARRY PROCESSING PLANT, SHOWING RAIL LOAD-OUT (RIGHT).**



through a 4 1/4 ft. standard cone crusher before rejoining the fines from the Tyler screen. This –4 in. material is sent to a 5 ft. x 12 ft. Cedarapids double–deck screen, from which + 2 1/2 in. and – 2 1/2 in. +7/8 in. stone can be sent for final screening with the –7/8 in. fines or routed by a gate to a 5 1/2 ft. cone crusher. If the +7/8 in. stone is recrushed, the product is sorted by a 6 ft. x 14 ft. double–deck Dillon screen. Plus 1 1/8 in. material is returned to the cone crusher while –1 1/8 in. +7/8 in. and –7/8 in. material is sent for final screening. This final screening is done in the Crusher Run bin building and incoming stone can be diverted as 3/4 in. or 2 in. crusher run to a stockpile or bin storage, or sent to a 6 ft. x 16 ft. triple–deck Tyler 990 screen, producing septic stone (+7/8 in.), HL8 mix and screenings. These products are stored in bins and can be directly loaded to rail cars.

Material in the –10 in. surge pile can be either processed as above or sent to Building #1 for secondary crushing and screening. There, a double–deck screen separates +3 in. stone for recrushing in a 4 1/4 ft. standard cone; –3 in. +3/4 in. stone is sent for recrushing or direct screening, and –3/4 in. is sent for direct screening or stockpiling as 3/4 in. crusher run. The material from the cone crusher is added to the direct screening feed, and sent to either of two 4 ft.x 12 ft. triple–deck Dillon screens. One screen feeds +3 in. and +1 1/2 in. oversize to a 3 ft. shorthead cone crusher, the other feeds +2 1/2 in. and +1 1/2 in. oversize to a 4 ft. shorthead cone, the products of both cone crushers being added to the –1 1/2 in. +7/8 in. and –7/8 in. material from the screens and sent to the Bin Building (Old Mill) for final screening.

The incoming feed at the Bin Building goes to either of two 4 ft. x 12 ft. double–deck Dillon screens, producing +2 1/2 in. oversize that is sent to a surge bin; –2 1/2 in. + 1 1/2 in. that goes to the surge bin or a 2 in. clear bin; and –1 1/2 in. fines that are fed directly to a pair of 5 ft. x 12 ft. double–deck Dillon screens. These screens produce +1 in. material to a surge bin or 1 in. clear bin, –1 in. +5/8 in. to surge bin or 3/4 in. clear bin, and –5/8 in. fines to a pair of 5 ft. x 14 ft. triple–deck Dillon screens. The triple–deck screens produce +3/8 in. stone, sent to the 3/4 in. bins, HL3 or HL8, and screenings (to the grit bin). The + 2 1/2 in. stone in the surge bin is fed to two 4 ft. Symons shorthead cone crushers and sent to two 6 ft. x 16 ft. triple–deck Dillon screens. A +7/8 in. or + 9/16 in. oversize is returned to the Symons cone crushers while HL3 or HL8, 1/4 in. chips and screenings are separated and sent to bin storage.

## PRODUCTS

Gabion Stone
  –12 in. + 6 in. and –6 in. + 4in.
Riprap 6 in. –12 in.
2 in. Crusher Run
3/4 in. Crusher Run
Granular "A"
2 in. Clear
1 in. Clear
3/4 in. Clear
Screenings
Shot Rock
HL3, HL4, HL6, HL8
1/4 in. Chips
3/8 in. Chips
Agricultural Lime

## REFERENCES

Caley and Liberty, 1950c, p.6
Hewitt, 1960, p.31–35
Hewitt, 1964a, p.28
Liberty, 1969b, pp.98, 101
Hewitt and Vos, 1972, p.28–29

Ryell et al., 1974
Dolar-Mantuani, 1975, p.8–22

### MAPS

Caley and Liberty, 1950b, GSC Map 50–11A
Liberty, 1969a, GSC Map 1228A

## H-6 FOWLER CONSTRUCTION CO. LTD. — WOODS (LONGFORD) QUARRY

### LOCATION AND OWNERSHIP

The Woods Quarry is located near Longford Mills on Simcoe Rd. 44, in Lots 26–29, Broken Front Concession, Rama Township, Simcoe County (Figure H–6–1). The quarry was first opened in the early 1900s and is the northernmost of a string of quarries, now abandoned, that were once important sources of building stone (Parks, 1912; Goudge, 1938). The "Longford" and "Rama" stones were the most important and were used for the construction of commercial buildings in Toronto. Detailed descriptions of some of the old quarries are presented by Hewitt (1960; 1964b). The quarry was licensed in 1979 to the present owner and operator, Fowler Construction Co. Ltd. The quarry licence covers 25.87 ha.

### GEOLOGY

The geological section in the quarry consists of 5.1m of the middle and upper members, Gull River Formation, which are overlain by 0.3m of lower Bobcaygeon Formation (Liberty, 1969b). Green dolostones of the lower member, Gull River Formation, occur just below the quarry floor. The middle member consists of medium-bedded, microcrystalline limestone. The upper member is a thin- to medium-bedded, microcrystalline to fine-crystalline limestone which is, in part, transitional to the overlying Bobcaygeon Formation. The lower member, Bobcaygeon Formation, is a thin-bedded, coarse-crystalline limestone interbedded with coarse-grained calcarenites. Glacial overburden around the quarry is less than 0.5 m thick.

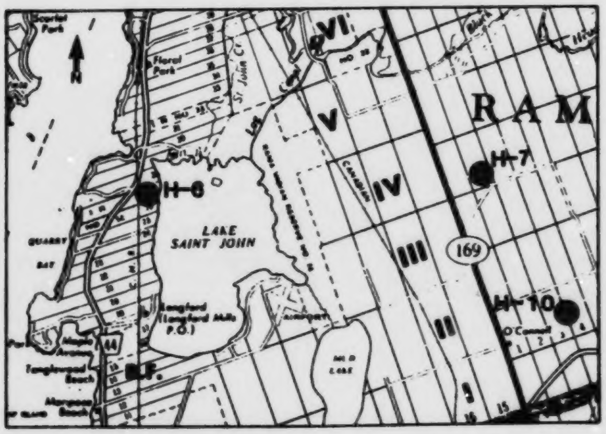


Figure H-6-1. LOCATION MAP FOR WOODS (LONGFORD) QUARRY.

### Geological Section

*Thickness*

*UNIT 4 Bobcaygeon Formation, lower member* *0.3m*

Limestone: light grey-brown; weathers light brown; coarse to very coarse crystalline; also coarse-grained calcarenites present; thin bedded (5–10 cm), sharp contacts; fossiliferous with all types present; distribution of unit is patchy due to irregular topography around quarry; lower contact of unit sharp and irregular.

*UNIT 3 Gull River Formation, upper member* *2.0m*

Limestone: mottled light grey and light brown, weathers dark grey; microcrystalline to fine crystalline; medium to thick bedded (10–40 cm), sharp, irregular, stylolitic contacts in places; thin intervals of coarse-crystalline limestone; sparsely fossiliferous with some burrows present; unit is transitional from Gull River to Bobcaygeon Formation; lower contact of unit sharp and irregular.

*UNIT 2 Gull River Formation, middle member* *1.2m*

Limestone: white to cream to medium grey, weathers same; microcrystalline, with a lithographic texture; medium to thick bedded (20–40 cm), stylolitic contacts and numerous stylolites within beds; abundant, small patches of calcite crystals ("birdeye" texture); sparsely fossiliferous; lower contact of unit sharp at base of 2 cm thick soft, recessive green shale.

*UNIT 1 Gull River Formation, middle member* *1.9m*

Limestone: light brown, weathers light grey-brown; microcrystalline, with a lithographic texture; medium bedded (20–30 cm), stylolitic contacts; throughout unit several thin interbeds of light green, shaly limestone, medium to coarse crystalline, with abundant ostracods; abundant patches of calcite crystals ("birdseye" texture).

*Total thickness* *5.4m*

### QUARRY OPERATION

The quarry has a disturbed area of about 5 ha, on a single lift of up to 5.7 m.

Drilling and blasting is performed by Fowler Construction Co. Ltd. A drill pattern of 2.4 m x 2.7 m is used with a 63.5 mm blast hole diameter. AN/FO is used as the explosive charge wherever possible but when encountering wet conditions, Powerfrac stick powder is used to achieve good fragmentation.

### PROCESSING

A Cat 980C loader is used to haul shot rock to the primary crusher, a Cedarapids 27 in. x 42 in. jaw feeding a secondary 54 in. Eljay cone crusher. The stone is screened beside the Eljay cone, producing HL4, Granular "A", and oversize that is sent to an 18 in. x 30 in. Pioneer roller crusher. The roller crusher is equipped with a 5 ft. x 18 ft. screen which produces 1 in. clear, 3/4 in. clear, and Granular "A".

### PRODUCTS

Granular "A"
1 in. Clear
3/4 in. Clear
HL4

### REFERENCES

Parks, 1912, p.229–231
Goudge, 1938, p.135–138
Caley and Liberty, 1950c, p.7
Hewitt, 1960, p.37–40
Hewitt, 1964b, p.31–37
Liberty, 1969b, p.98

### MAPS

Caley and Liberty, 1950b, GSC Map 50–11A
Liberty, 1969a, GSC Map 1228A

## H-7 RAMA TOWNSHIP QUARRY

### LOCATION AND OWNERSHIP

This small quarry, 3.5 km east of Lake St. John, is operated intermittently by Rama Township with portable equipment. It is located in Lot 2, Concession E, Rama Township, Simcoe County (Figure H-7-1).

### GEOLOGY

The geological section consists of 5.0 m of limestones and dolomitic limestones of the lower member of the Gull River Formation (Figure H-7-2). Green sandy limestone of the Shadow Lake Formation is exposed in the quarry floor. Glacial overburden around the quarry is less than 0.5 m thick.

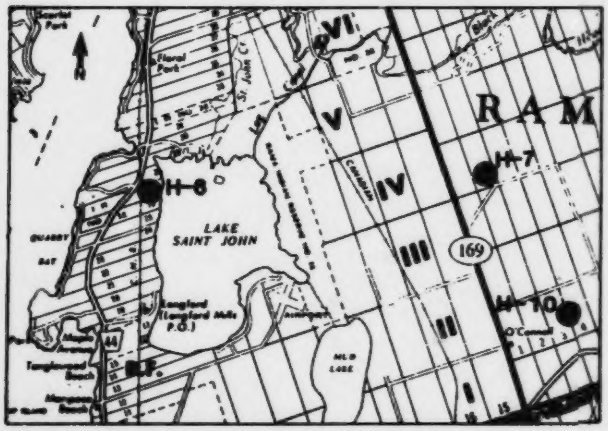


Figure H-7-1. LOCATION MAP FOR RAMA TOWNSHIP QUARRY.

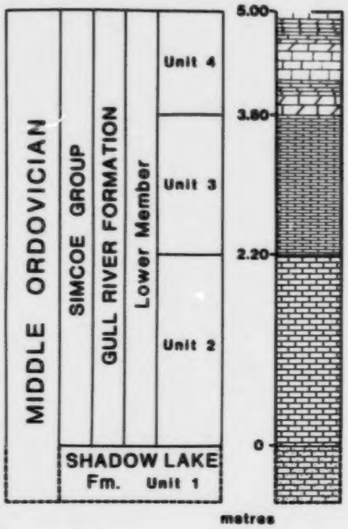


Figure H-7-2. STRATIGRAPHIC COLUMN FOR RAMA TOWNSHIP QUARRY.

### Geological Section

*Thickness*

*UNIT 4 Gull River Formation, lower member* *1.2m*

Limestone and dolomitic limestone: mottled light grey and grey-brown, weathers light grey and brown; dolomitic limestone is fine crystalline; limestone is microcrystalline with a lithographic texture; thin to medium bedded (5–15 cm), with sharp, slightly irregular, stylolitic contacts; small patches of calcite crystals ("birdseye" texture) present, some with small gypsum crystals in centre; rare burrows; lower contact of unit sharp and planar.

*UNIT 3 Gull River Formation, lower member* *1.6m*

Limestone: light grey, weathers same; microcrystalline to very fine crystalline; thin bedded (5–10 cm), stylolitic contacts; light green glauconite coats burrows, fossils and bedding planes; small patches of calcite crystals ("birdseye" texture) common; small pyrite crystals present rarely; white, brittle chert nodules in upper 50 cm; fossiliferous with abundant brachiopods, crinoidal debris and burrows; lower contact of unit sharp and planar.

*UNIT 2 Gull River Formation, lower member* *2.2m*

Limestone: light grey to light grey-brown, weathers light grey; microcrystalline to very fine crystalline with a lithographic texture in places; medium bedded (15–30 cm), with sharp, planar, sometimes stylolitic contacts; glauconite coats fossils and lines burrows; small patches of calcite crystal ("birdseye" texture) common; fossiliferous with many fragments and burrows; lower contact of unit sharp and planar at quarry floor.

*UNIT 1 Shadow Lake Formation* *(quarry floor)*

**Sandy limestone: light green, weathers same; very fine-crystalline limestone with medium- to coarse-grained quartz; unit is only exposed in patches around quarry floor.**

*Total Thickness* *5.0m*

## CHEMICAL ANALYSES

**Components in Percent**

| | | | |
|---|---|---|---|
| $SiO_2$ | 4.60 | CaO | 47.7 |
| $Al_2O_3$ | 2.06 | L.O.I. | 40.9 |
| $Fe_2O_3$ | 0.94 | TOTAL | 99.93 |
| MgO | 3.73 | | |

*Source: Hewitt and Vos, 1972, p.39.*

## REFERENCES

Hewitt and Vos, 1972, p.38–40

## MAPS

None

# H-8 MARA LIMESTONE AGGREGATES LTD. — GAMEBRIDGE QUARRY

## LOCATION AND OWNERSHIP

The Gamebridge Quarry, located 1 km northwest of Gamebridge in Lots 11 and 12, Concession A, Mara Township, Simcoe County (Figure H–8–1), is owned and operated by Mara Limestone Aggregates Ltd. and is licensed for 90.23 ha. The quarry now covers an area of 8 ha and produces road construction aggregates from a single lift of 10.5 m.

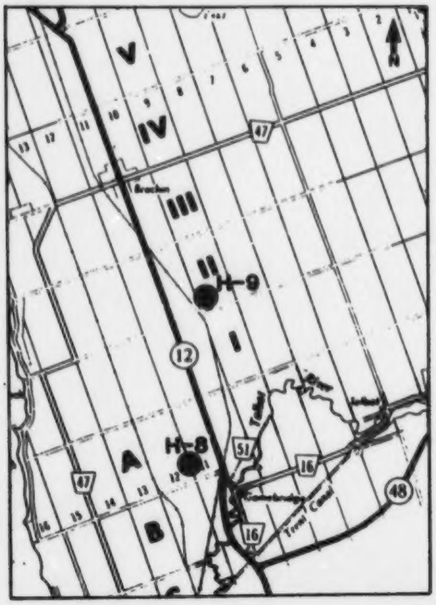


**Figure H-8-1. LOCATION MAP FOR GAMEBRIDGE QUARRY.**

## GEOLOGY

The 10.5 m deep quarry extends into a low escarpment of thin-bedded limestone, shaly limestone and shale of the Verulam Formation. The medium to dark grey limestone beds range from very fine-crystalline limestone to very coarse-grained calcarenites, with most beds consisting of medium to coarse-grained bioclastic limestone. The shaly limestone and shale beds are usually firm and only rarely form recessive units. As this rock is very fossiliferous and the fossils are well preserved, it is a popular site for fossil collectors. Glacial overburden around the quarry is usually less than 1 m thick.

### Geological Section

*Thickness*

*UNIT 1 Verulam Formation* *10.5m*

**Interbedded limestone, shaly limestone, and shale: medium to dark grey, weathers light to medium grey, tan in uppermost metre; limestone ranges from very fine crystalline to very coarse-grained calcarenite, usually a medium- to coarse-grained bioclastic limestone; limestone thin bedded (5–10 cm); shale and shaly limestone thinner bedded (3–5 cm); sharp, planar to irregular contacts; some coarser grained beds with small patches of calcite; very fossiliferous (including the bryozoa *Prasopora*; the brachiopods *Zygospira*, *Stegerhyncus*, *Sowerbyella*, and several strophomenids; crinoidal debris; trilobite fragments; and a large number of indeterminant fragments).**

*Total thickness* *10.5m*

## CHEMICAL ANALYSES

**Components in Percent**

| Metres above floor 5.5–10.5 | | Metres above floor 0–5.5 | |
|---|---|---|---|
| $SiO_2$ | 15.2 | $SiO_2$ | 17.2 |
| $Al_2O_3$ | 3.34 | $Al_2O_3$ | 4.56 |
| $Fe_2O_3$ | 1.37 | $Fe_2O_3$ | 1.72 |
| MgO | 1.28 | MgO | 2.09 |
| CaO | 42.1 | CaO | 39.0 |
| $P_2O_5$ | 0.08 | $P_2O_5$ | 0.11 |
| $SO_3$ | 0.88 | $SO_3$ | 1.28 |
| L.O.I. | 35.3 | L.O.I. | 33.3 |
| Total | 99.5 | Total | 99.3 |

*Source: Hewitt and Vos, 1972, p.29.*

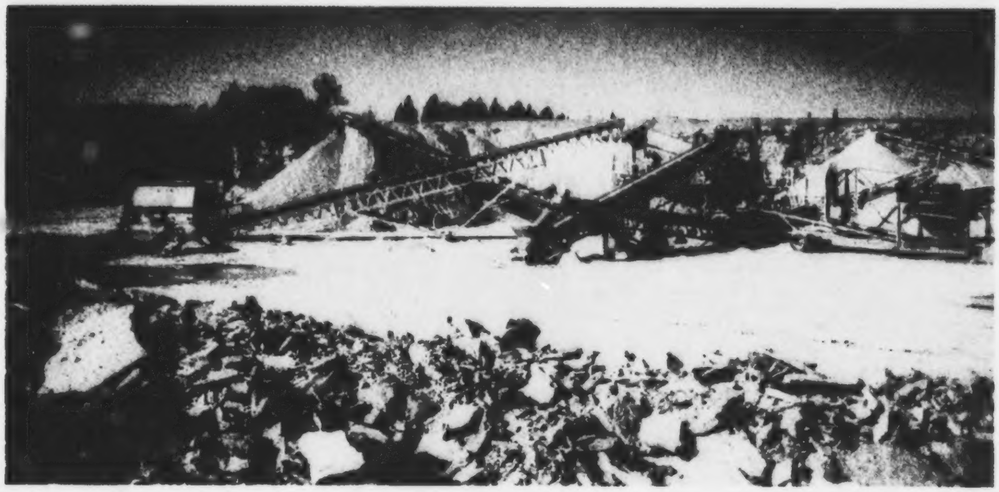
## QUARRY OPERATION

Drilling and blasting is performed by the company, using a 2.44 m x 2.44 m drill pattern with 7.6 cm diameter holes. AN/FO is used as the explosive agent and is initiated with electric blasting caps.

## PROCESSING

Shot rock is hauled by a single Trojan 175 (7 yd.) loader and two Komatsu 600 (6 yd.) loaders to the primary crusher, a Cedarapids impactor. The crushed stone is fed

Photo H-8-1. PRIMARY FEED HOPPER AND PORTABLE CEDARAPIDS IMPACTOR CRUSHER; GAMEBRIDGE QUARRY.



to a Tyler double-deck screen which produces 3/4 in. or 2 in. crusher run and a +2 in. oversize that is sent to two Skoda (4 ft.) cone crushers. Stone from the cone crushers is processed by two inclined Simplicity screens, producing 3/4 in. clear, HL 3, HL 6, and screenings.

### PRODUCTS

2 in. Crusher Run
3/4 in. Crusher Run
3/4 in. Clear
HL3
HL6
Screenings

### REFERENCES

Goudge, 1938, p.138-140
Caley and Liberty, 1950c, p.7
Liberty, 1969b, p.49
Hewitt and Vos, 1972, p.29
Waddington, 1980
Kobluk and Brookfield, 1982, p.38

### MAPS

Caley and Liberty, 1950a, GSC Map 50-11B
Liberty, 1969a, GSC Map 1228A

## H-9 STANDARD AGGREGATES LTD. — BRECHIN QUARRY

### LOCATION AND OWNERSHIP

The Brechin Quarry is located 2 km southeast of Brechin in Lots 7, 8, 9 and 10, Concessions 1 and 2, Mara Township, Simcoe County (Figure H-9-1). The quarry was opened in 1974 and has a licensed area of 331.85 ha. Standard Aggregates Ltd., the owner and operator of the quarry, ships much of the quarry production by contracted trailer trucks to the Toronto area.

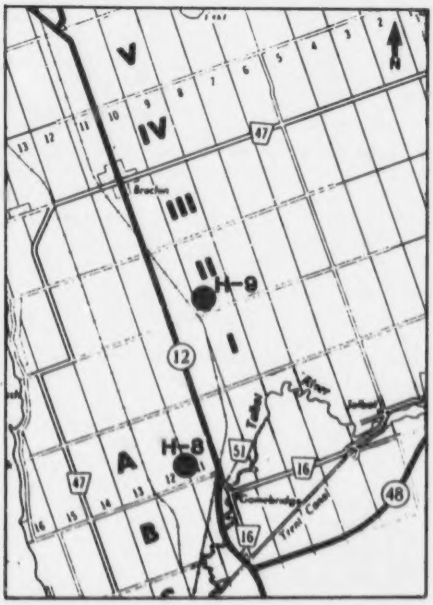


Figure H-9-1. LOCATION MAP FOR BRECHIN QUARRY.

### GEOLOGY

The three lifts of the quarry expose 21.5 m of limestones of the Bobcaygeon Formation overlain by 3.3 m of the

Verulam Formation (Figure H-9- 2). For the most part, the Bobcaygeon is a light to dark grey, sometimes brown limestone which weathers light grey. It is fine to coarse crystalline and medium bedded with sharp, slightly irregular bedding contacts separated by thin shale partings. It is very fossiliferous and is intensively burrowed. There are some distinctive coarse-grained beds which contain black chert nodules, rip up clasts, and abundant fossil fragments. Small calcite crystals occur as patches and infilling small vugs.

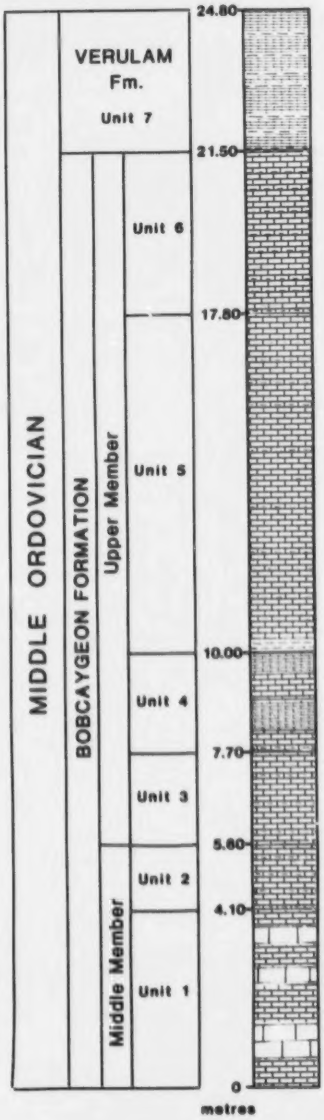


**Figure H-9-2. STRATIGRAPHIC COLUMN FOR BRECHIN QUARRY.**

The 3.3 m thick exposure of the Verulam Formation in this quarry consists of light to medium grey interbedded limestone and shale. The limestones are fine to medium crystalline and thin to medium bedded. The formation is very fossiliferous with brachiopods and bryozoans (e.g. *Prasopora*) most abundant. Glacial overburden around the quarry is thin.

### Geological Section

*Thickness*

*UNIT 7 Verulam Formation 3.3m*

**Interbedded limestone and shale: light to medium grey, weathers grey to grey-brown; fine to medium crystalline; thin bedded (5-8 cm), with thinner (2-5 cm) shale interbeds; upper 2 m of unit with even thinner (2-4 cm) limestone beds; fossiliferous with abundant bryozoans (e.g. *Prasopora*) in lower 1.3 m of unit and abundant brachipods and burrows throughout; lower contact of unit sharp and planar at base of 3 cm thick shale bed.**

*UNIT 6 Bobcaygeon Formation, upper member 3.7m*

**Limestone: medium grey, weathers same; medium crystalline; medium bedded (10-15 cm), sharp, irregular contacts with rare, shaly limestone partings less than 2 cm thick; very fossiliferous with abundant brachiopods, crinoidal debris, bryozoans (*Prasopora* very abundant); fossils mostly on bedding planes; lower contact of unit sharp at base of a 2 cm thick shaly limestone bed, which in turn is overlain by a 3 cm thick shale bed that contains numerous discrete burrows.**

*UNIT 5 Bobcaygeon Formation, upper member 7.8m*

**Limestone: medium to dark grey, weathers lighter grey; medium to coarse crystalline; medium bedded (20-25 cm), sharp and planar to slightly irregular contacts; 80 cm above base of unit is a thick, recessive, soft shale which is continuous around the quarry; some thin, fine-crystalline limestone beds occur throughout the unit which are a lighter grey, with upper contacts gradational and in rare cases lower contacts appear erosional; unit is very fossiliferous with many burrows also present; floor of upper lift covered with large megaripples of coarse-grained calcarenite.**

*UNIT 4 Bobcaygeon Formation, upper member 2.3m*

**Limestone: medium grey, weathers light grey; very fine to fine crystalline; thin to medium bedded (5-15 cm), very irregular, discontinuous contacts; some interbeds of coarse-grained calcarenites with internal slumping, rip-up clasts, very abundant fossil fragments, large black chert nodules up to 5 cm thick, and with very sharp, irregular, erosional basal contacts; fossiliferous with abundant brachiopods, gastropods throughout unit; lower contact of unit sharp at thin shaly limestone bed.**

*UNIT 3 Bobcaygeon Formation, upper member 2.1m*

**Limestone: grey-brown to medium grey, weathers light grey-brown; very fine to coarse crystalline; medium bedded (15-20 cm), sharp contacts with up to 3 cm thick shaly limestone partings; some alternating coarse-grained calcarenites and very fine-crystalline beds with very sharp, irregular, erosional basal contacts, with burrows extending down into underlying bed from surface; very fossiliferous.**

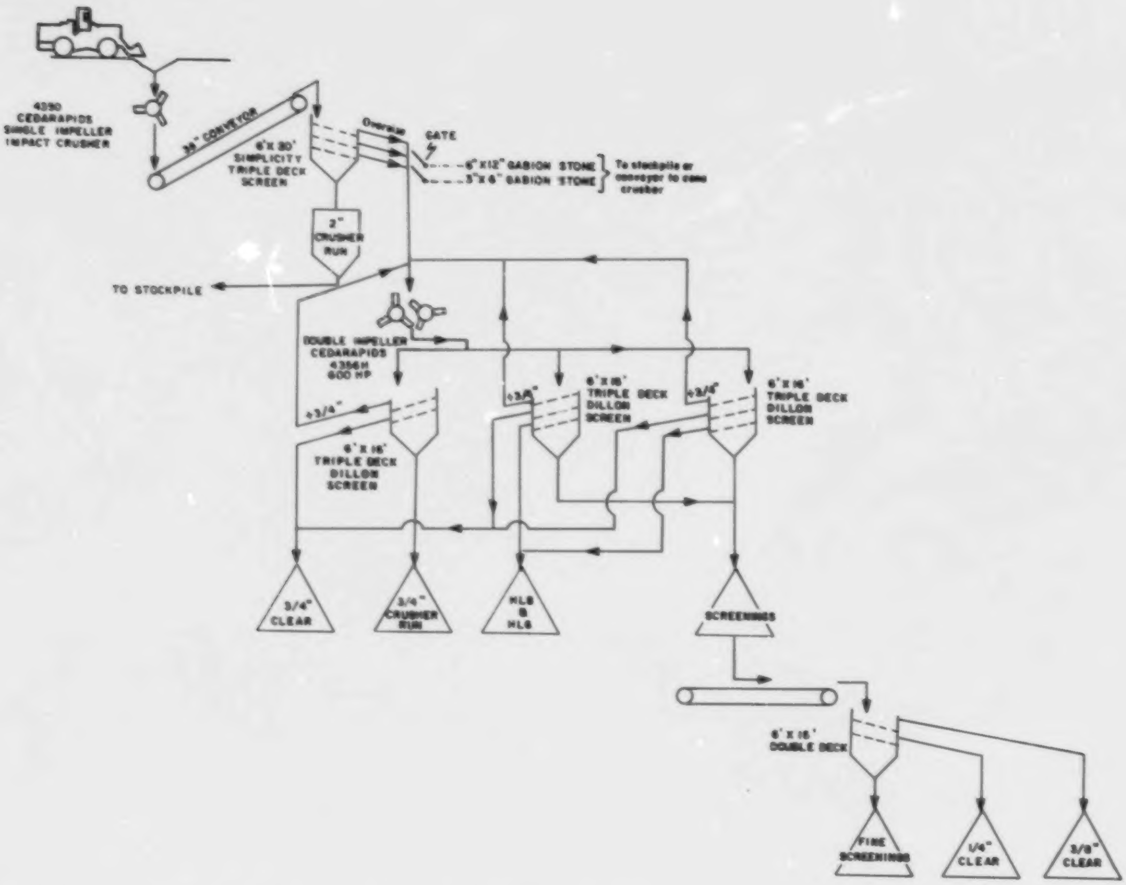

4330
CEDARAPIDS
SINGLE IMPELLER
IMPACT CRUSHER
36" CONVEYOR
6'X 20'
SIMPLICITY
TRIPLE DECK
SCREEN
Oversize
GATE
6"X12" GABION STONE
3"X6" GABION STONE
To stockpile or conveyor to cone crusher
2"
CRUSHER
RUN
TO STOCKPILE
DOUBLE IMPELLER
CEDARAPIDS
4356H
600 HP
+3/4"
6'X16'
TRIPLE DECK
DILLON
SCREEN
+3/8"
6'X16'
TRIPLE DECK
DILLON
SCREEN
+3/4"
6'X16'
TRIPLE DECK
DILLON
SCREEN
3/4"
CLEAR
3/4"
CRUSHER
RUN
HLS
&
HL6
SCREENINGS
6'X16'
DOUBLE DECK
FINE
SCREENINGS
1/4"
CLEAR
3/8"
CLEAR

Figure H-9-3. PROCESS FLOW SHEET FOR BRECHIN QUARRY.

*UNIT 2 Bobcaygeon Formation, middle member* *1.5m*

Limestone: medium to dark grey, weathers medium grey; fine to medium crystalline; medium bedded (10–15 cm), sharp, very irregular contacts due to thin, platy, shaly limestone partings; numerous thin intervals of microcrystalline limestones and very coarse-grained calcarenites; very fossiliferous especially on bedding planes; lower contact of unit sharp, at base of 2 cm thick shale bed.

*UNIT 1 Bobcaygeon Formation, Middle Member* *4.1m*

Limestone: light to dark grey and light grey-brown, weathers light grey, fine to medium crystalline; medium to thick bedded (20–40 cm), sharp, irregular contacts; upper 1m contains irregular microcrystalline limestone patches; rare vugs filled with calcite crystals; fossiliferous.

*Total thickness* *24.8m*

## QUARRY OPERATION

The quarry is excavated on 12.4 m benches and reaches a depth of 24.8 m on the north and west faces. The eastern quarry face is currently mined on the second bench (12 m to 24 m depth) for the extraction of concrete stone products. A third bench is in the initial stages of development (6.1 m, 1 lift) and will ultimately reach a depth of 36.6 m.

Drilling is carried out with an Atlas Copco hydraulic drill. An 11 ft. x 11 ft. drill pattern with 4 in. diameter drill holes is used. Blast holes are loaded with AN/FO and initiated by electric blasting caps.

Photo H-9-1.
BRECHIN QUARRY PROCESSING FACILITIES.

## PROCESSING

The process flow sheet is shown on Figure H-9-3. Blasted stone is hauled by Cat 992 and 988B loaders to the primary crusher (5348 Cedarapids single impact) located within the pit. The crushed stone is conveyed by a 36 in. belt to a 6 ft. x 20 ft. Simplicity triple-deck screen producing +12 in. oversize to a secondary crusher (4350 Cedarapids double impact), 6 to 12 in. and 3 to 6 in. gabion stone to stockpiles or the secondary crusher, and 2 in. crusher run to a stockpile. The secondary crushed stone is screened by three 6 ft. x 16 ft. Dillon triple-deck screens. Two of the screens produce +3/4 in. oversize that is returned to the secondary crusher, 3/4 in. clear stone, HL8 or HL6, and screenings. The third screen produces 3/4 in. crusher run. The screening stone can be separated if required by a 6 ft. x 16 ft. double-deck screen into 3/8 in. chips and fine screenings.

## PRODUCTS

Gabion Stone – 12 in. + 6 in.
Gabion Stone – 6 in. + 3 in.
2 in. Crusher Run
3/4 in. Crusher Run
3/4 in. Clear
3/8 in. Clear
1/4 in. Clear
HL6
HL8
Screenings

## REFERENCES

None

## MAPS

None

# H-10 C.S. SPEIRAN – SPEIRAN QUARRY

## LOCATION AND OWNERSHIP

The Speiran Quarry is located in Lots 3 and 4, Concession B, Rama Township, Simcoe County, about 1 km east of Highway 169 (Figure H-10-1). The quarry is intermittently operated by the owner, Carson S. Speiran.

## GEOLOGY

The quarry exposes surface-weathered limestones of the Gull River Formation. The limestone is thick bedded (20–30 cm) with numerous superimposed partings at intervals of 2–8 cm, along which the slabs may tend to break. The limestone is microcrystalline and pale grey in colour, weathering to grey-white. A uniform, flat quarry floor reveals a regular pattern of vertical joining in east–

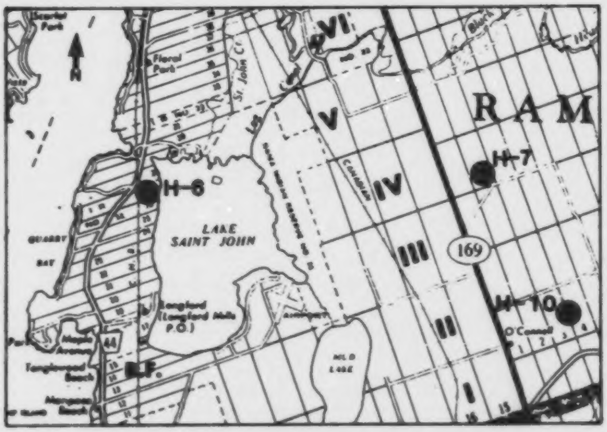


Figure H-10-1. LOCATION MAP FOR SPEIRAN QUARRY.

Photo II-10-1. BLOCKS OF GULL RIVER FORMATION LIMESTONE AT THE SPEIRAN QUARRY.

west and north–south directions, spaced at 1 m and 1–3 m, respectively.

## QUARRY OPERATION

Extensive shallow excavations covering several hectares are located on a broad flat limestone plain. Only the top 50 cm of the thick and eroded limestone slabs are taken, for use as landscape stone in rock gardens and retaining walls. Quarrying is accomplished solely by forklift and front–end loader.

## REFERENCES

None

## MAPS

None

# Maple District

## INTRODUCTION

Maple District is situated in the Central Region of southern Ontario, bounded on the east by the Lindsay District, on the south by Lake Ontario, on the west by the Cambridge District and on the north by the Huronia District, and includes Metropolitan Toronto, all of the Regional Municipalities of Peel and York, and the western part of Durham (Figure MA-0-1).

The St. Lawrence Cement Company Inc. (site no. MA-1) operates a cement manufacturing plant in Mississauga (Clarkson) which was visited during the study.

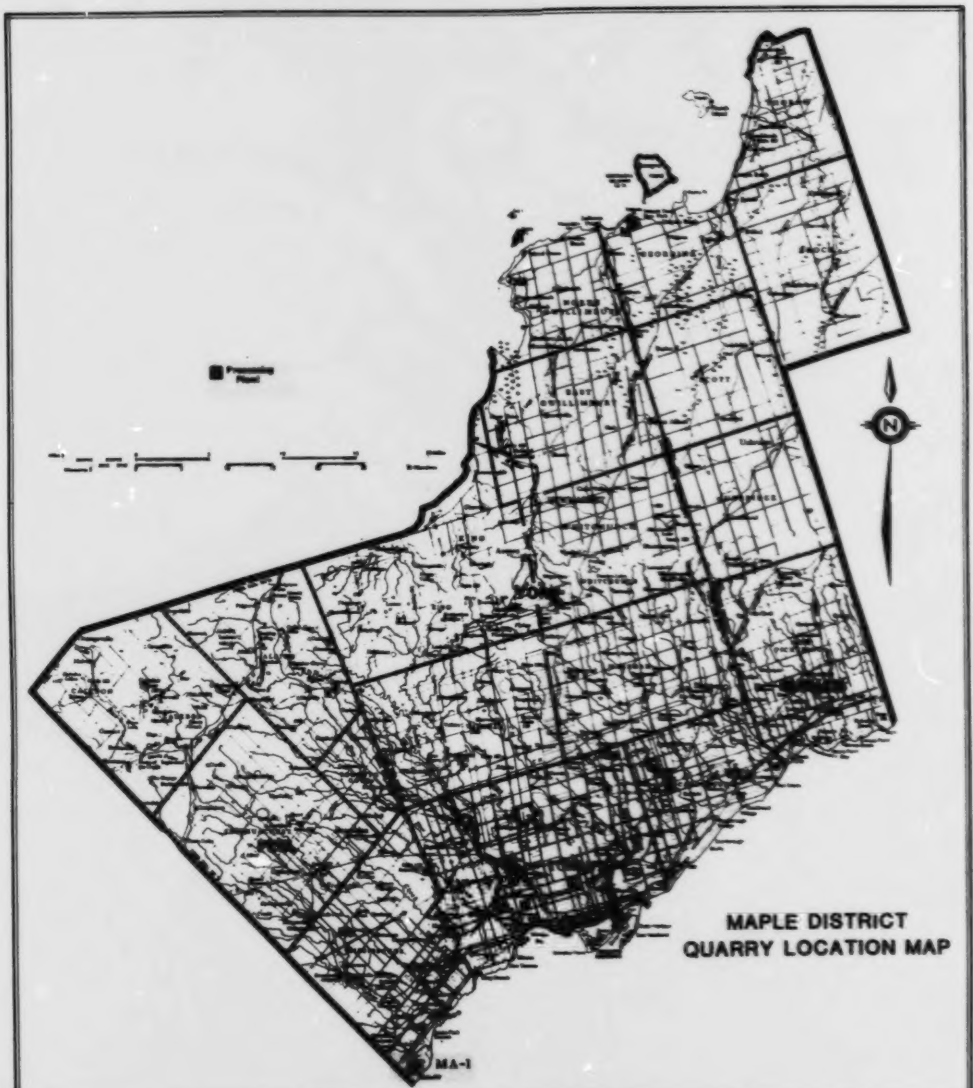


Figure MA-0-1. MAPLE DISTRICT QUARRY LOCATION MAP.

Nine inactive quarries in Maple District are documented in Appendix IV of Volume I.

## REGIONAL GEOLOGY

Paleozoic strata present within Maple District range in age from Middle Ordovician to Middle Silurian. Apart from exposures of Silurian age rocks along the Niagara Escarpment, which crosses the extreme western portion of the district, and scattered outcrops of Ordovician age rocks in the Lake Simcoe area, these strata are poorly exposed. This is a result of the nearly flat-lying nature of the strata and the thick Quaternary deposits which cover the central portion of the district. Ordovician units present in this district are (in ascending stratigraphic order): the Verulam, Lindsay, Blue Mountain, Georgian Bay and Queenston Formations. Details of these units can be found in the introduction chapter and in the geological introduction to the Huronia District. Silurian age units present along the Niagara Escarpment include: the Whirlpool, Manitoulin, Cabot Head, Fossil Hill and Amabel formations. For details of these units see the geological introduction to the Cambridge District.

## LIMESTONE INDUSTRIES

The principal limestone industry in the Maple District is cement. Cement production in 1985 was approximately 1,360,300 tonnes (1986 Ontario Mineral Score) and was produced by the St. Lawrence Cement Company Inc. at their Mississauga (Clarkson) plant (MA–1).

## MA–1 ST. LAWRENCE CEMENT COMPANY INC. – MISSISSAUGA (CLARKSON) PLANT

### LOCATION AND OWNERSHIP

The St. Lawrence Cement Company Inc. operates a 1.9 million tonnes per year cement plant at Mississauga (Clarkson). The plant was originally built in 1956 and is located immediately north of Highway 2, approximately 1 km west of Southdown Rd. The plant is the largest cement operation in Canada and includes one dry process and two wet process kilns.

### RAW MATERIAL RECEIVING/STORAGE

Limestone for the plant is received by ship from the St. Lawrence Cement Co. quarry at Ogden Point (Colborne), Ontario (site NP–1, Volume II). Stone is unloaded from self–unloading vessels onto a 1,680 m long, 3,000 tonnes/hr. HTS covered belt conveyor. The limestone averages –200 mm in size. The stone is conveyed to the back of the plant where it is piled by a rotating stacker. The storage area holds approximately 1 million tonnes of stone that is reclaimed by means of an underground tunnel system.

The stone from Ogden Point yields a clinker with a $C_3S$ of 70%. Supplemental shale is ripped at the plant site from a small quarry and stored adjacent to the limestone pile. The company is gradually reducing the amount of shale used and replacing it with coal ash. Currently, approximately 12% coal ash is used in place of the shale.

Type 2 cement and low alkali cement production require the use of a limestone sweetener. High calcium limestone screenings from BeachviLime Ltd. in Beachville, Ontario are used to supplement the raw feed. This material is received by truck or rail. Gypsum is received by boat, truck or rail and stored in the open adjacent to the limestone.

All of the kilns are coal fired, although oil and natural gas are available as stand–by fuels. Coal is received from self–unloading vessels onto a 1,680 m long, 2,000 tonnes/hr. HTS covered belt conveyor. This conveyor leads to a 385 m long, 2,000 tonnes/hr. Stephens–Adamson belt conveyor located at the rail siding. (Some coal is also received by rail.) There is provision for 100,000 tonnes of open storage for coal. Reclamation of the coal from storage is by means of an underground tunnel belt conveyor that transfers the coal to the preparation plant.

Other raw materials such as mill scale, silica sand, etc. are received by truck and placed in storage silos.

### RAW GRINDING/MIXING

Limestone and other raw materials from storage are transferred by belt conveyor to a 315 tonnes/hr. 8.2 m x 1.7 m Aerofall dry autogenous ball mill for crushing. The crushed stone is passed through a series of cyclones with the tailings going to two 90 tonnes/hr. 3.0 m x 8.5 m Allis–Chalmers regrind mills. A Joy Manufacturing Co. electrostatic precipitator is attached to the Aerofall mill, the precipitated material being returned to the Aerofall mill. Material from the regrind mills is passed to four raw meal storage silos, 56.3 m high x 13.3 m diameter, of 8,100 tonnes capacity each.

Limestone may also be reclaimed and processed to 15.2 mm size through a 315 tonnes/hr. Pennsylvania impact crusher. This material along with other raw materials, is then passed to three 2.4 m x 11.3 m 54 tonnes/hr. Allis–Chalmers slurry mills for further grinding. Screenings from the Aerofall mill may also be used in the slurry grinding process. The finished slurry is pumped to four 7.6 m high x 24.2 m diameter Dorr–Oliver slurry basins. Each basin contains 3,534 $m^3$ of slurry.

At the present time low alkali and other special cements are made using the wet process kilns. The company is installing equipment and modifying the process to enable the manufacture of cements on the dry kiln. This will require the use of larger benches at the Ogden Point quarry to yield a natural cement stone, as well as the use of $CaCl_2$ in the raw mix to volatize the alkalis during clinker formation. The wet process kilns will be placed on stand-by and used as reserve manufacturing capacity when the modifications to the quarry and the plant are complete.

### KILNS

Coal for all of the kilns is prepared in a KVS 32 tonnes/hr. 3.9 m x 5.8 m coal mill rated at 1,119 kw. The coal is processed to 90% passing 200 mesh. The company has experimented extensively with the use of refuse derived fuel and burning of solvents and waste oils. These experiments have proven to be highly successful and may eventually result in the use of fuel substitutes for approximately 15–20% of total fuel requirements. Currently, coal requirements are approximately 900 tonnes/day.

There are two Allis–Chalmers wet process oil–fired kilns. Each kiln measures 123 m long x 4.0 m – 3.5 m diameter. Each kiln is rated at 900 tonnes/day capacity and has two 75 kw drives. Clinker is discharged to a 720–990 tonnes/day Fuller cooler which is fitted with a Lurgi gravel bed filter.

Raw meal from the storage silos is passed to the dry kiln which is fitted with a Fuller–Humboldt twin suspension 4–stage preheater/precalciner system each rated at 2,100 tonnes/day. Raw meal leaves the first stage at 560°C and leaves the fourth stage at 880°C. The preheater is equipped with a 10% by–pass system but is normally run at 4–5% by–pass due to the 0.5% $Cl_2$ content in the Ogden Point limestone. The preheater/precalciner is equipped with two Joy Manufacturing electrostatic precipitators, and is fitted with a 26.1 m high x 3.96 m diameter conditioning tower and an SF Products precipitator.

The dry process kiln is a 84.1 m x 5.2 m Fuller–Traylor rotary unit rated at 4,500 tonnes/day. Available capacity has averaged 4,200 tonnes/day. Clinker is cooled in a Fuller cooler measuring 3.0 m x 7.6 m and 3.6 m x 21.3 m, with total capacity rated at 4,200 tonnes/day. The kiln is fitted with a Lurgi gravel bed filter.

Cooled clinker from both the wet and dry kilns is transferred by bucket elevator to a clinker storage building or clinker storage silos. The clinker storage building is fitted with an 18–ton Provincial Engineering bucket crane on a 36.5 m span. The storage silos measure 61 m high x 33.5 m diameter and hold 76,500 tonnes each.

### FINISH GRINDING

Clinker is reclaimed from storage and processed in a series of finish mills. There are five Allis–Chalmers 3.0 m x 8.5 m mills rated at 933 kw, each with a capacity of 33 tonnes/hr. There is also a larger Allis–Chalmers mill measuring 3.96 m x 12.8 m and rated at 2,984 kw and 80 tonnes/hr.; and a 3.18 m x 17.1 m Aerofall mill rated at 6,528 kw with a capacity of 170 tonnes/hr. Total cement grinding capacity is rated at 2.5 million tonnes per year. The mills are fitted with air classifiers in closed circuit. There are five Sturtevant separators of 4.8 m diameter rated at 93 kw, two Combustion Engineering separators measuring 5.5 m and rated at 187 kw each, and two GATX–Fuller separators measuring 6.7 m and rated at 112 kw each. The ground cement is cooled in nine F.L. Smidth cement coolers measuring 1.9 m diameter. Each cooler has a capacity of 90 tonnes/hr. and is rated at 45 kw.

### PACKING

Finished cement for truck bulk shipping is transferred to storage in 4 silos. Two of the silos measure 58.1 m high x 15.8 m diameter and hold 13,500 tonnes each; the other two silos measure 61.2 m high x 18.3 m and hold 20,000 tonnes each. Two 32–tonne Streeter Amet scales are associated with the silos.

Cement storage for shipment in bags and by bulk rail and truck consists of 20 silos measuring 16.5 m high x 11.6 m diameter, each holding 1,350 tonnes. There are five Consolidated–Bathurst Packaging bag packing machines.

Facilities are available for shipment of cement by boat. Finished cement is recovered from storage and transferred by pneumatic screw pump, conveyor, and air slide for loading at the dock. Clinker may also be shipped by boat. The clinker is recovered from storage and transferred by a 1,680 m long, 2,000 tonnes/hr. HTS conveyor to the shiploader on the dock.

# Cambridge District

## INTRODUCTION

The Cambridge District is situated in the Central Region of southern Ontario and includes all or portions of Brant, Dufferin, Oxford and Wellington Counties and the Regional Municipalities of Halton, Hamilton–Wentworth and Waterloo, as shown in Figure CB–0–1.

Twenty quarry properties are currently licensed for limestone/dolostone extraction in the Cambridge District; ten are active at the present time. The balance of the properties represent past–producing quarries or those properties identified for future production. The majority of the quarries are located along the Niagara Escarpment and include several of the largest in southern Ontario.

A total of sixty–six quarries have been identified in the district (Appendix IV, Volume I). All of the quarries currently in production and those past–producing quarries of geological significance were visited during the study and include the following:

| | |
|---|---|
| *CB–1* | *Guelph Correctional Centre Quarry (abandoned)* |
| *CB–2* | *Guelph Dolime Ltd. – Quarry and Lime Plant (active)* |
| *CB–3* | *United Aggregates Ltd. – Acton Quarry (active)* |
| *CB–4* | *Dufferin Aggregates – Milton (Dufferin) Quarry (active)* |
| *CB–5* | *Halton Crushed Stone Ltd. – Halton Quarry (active)* |
| *CB–6* | *Milton Limestone – Milton Quarry (active)* |
| *CB–7* | *Nelson Aggregate Co. – Nelson Quarry (active)* |
| *CB–8* | *Old Nelson Quarry (abandoned)* |
| *CB–9* | *Flamboro Quarries Ltd. (active)* |
| *CB–10* | *Clappison's Corners Quarry (abandoned)* |
| *CB–11* | *Steetley Lime and Aggregates Division – Dundas Quarry (active)* |
| *CB–12* | *Taro Aggregates – Stoney Creek Quarries (active)* |
| *CB–13* | *Waterford Sand and Gravel Ltd. – Vinemount Quarry (active)* |

The Cambridge plant of Arriscraft Corp. (CB–14) was also visited.

## REGIONAL GEOLOGY

The dominant geomorphic features in the Cambridge District are the north–south trending Niagara Escarpment, Lake Ontario to the east, the deeply incised Grand River valley at Elora–Fergus, and the Dundas Valley located at the west end of Lake Ontario. The Niagara Escarpment provides excellent exposure of Middle Silurian stratigraphy, consisting predominantly of dolostones and dolomitic limestones. The easily eroded underlying Ordovician shales produce an irregular terrain at the base of the Escarpment and eastward to the shoreline of Lake Ontario. West of the Escarpment, Quaternary cover becomes progressively thicker and outcrops become sparse. Scattered bedrock exposures occur near Paris, Boston Creek and Mineral Springs (in the southwest corner of the District), along the Grand, Speed and Eramosa River valleys (in the west–central portion), and around Rockwood and Acton. Consequently, most major operating quarries are located along the Niagara Escarpment, except for the Guelph Dolime Quarry (CB–2), located next to the Speed River in Guelph and the Flamboro Quarries Ltd. Quarry (CB–9) in Flamborough, which operate in areas of thin overburden cover.

The oldest unit which subcrops in the Cambridge District is the Upper Ordovician Georgian Bay Formation. It consists of green–grey to blue shales with interbeds of green–grey siltstones and grey argillaceous limestones. The unit outcrops along the shoreline of Lake Ontario and in steep–sided stream valleys. The Upper Ordovician Queenston Formation gradationally overlies the Georgian Bay Formation, consists predominantly of red, hematitic shale and forms the majority of the bedrock east of the Escarpment. This formation is quarried extensively for the manufacture of ceramic products and bricks and is overlain sharply and disconformably by the Lower Silurian Cataract Group.

The Cataract Group consists of four formations (in ascending stratigraphic order): the Whirlpool, Manitoulin, Cabot Head, and Grimsby. They respectively consist of grey–brown, quartz sandstone; grey–brown, argillaceous dolostones; grey–green shales with interbeds of fine–crystalline limestones and occasional siltstones; and fine–grained red sandstones with interbedded shales. The Whirlpool Formation is quarried extensively for building stone in the region from Limehouse north to Terra Cotta. The Cabot Head Formation is exposed in the Dufferin Quarry (CB–4) by a deep pit which was excavated for the primary crusher, and in the Halton Quarry (CB–5) where the formation is exposed in a sump pit. The Cataract Group is overlain by the Clinton Group which consists of five formations (in ascending stratigraphic order): the Thorold, Reynales, Irondequoit, Rochester and Decew. These formations include, respectively, fine–grained sandstones; fine–crystalline dolostones with irregular shale partings; limestones; shales with interbeds of fine–crystalline limestones and dolostones; and very fine–crystalline dolostones. The Reynales Formation changes character northward in the district to

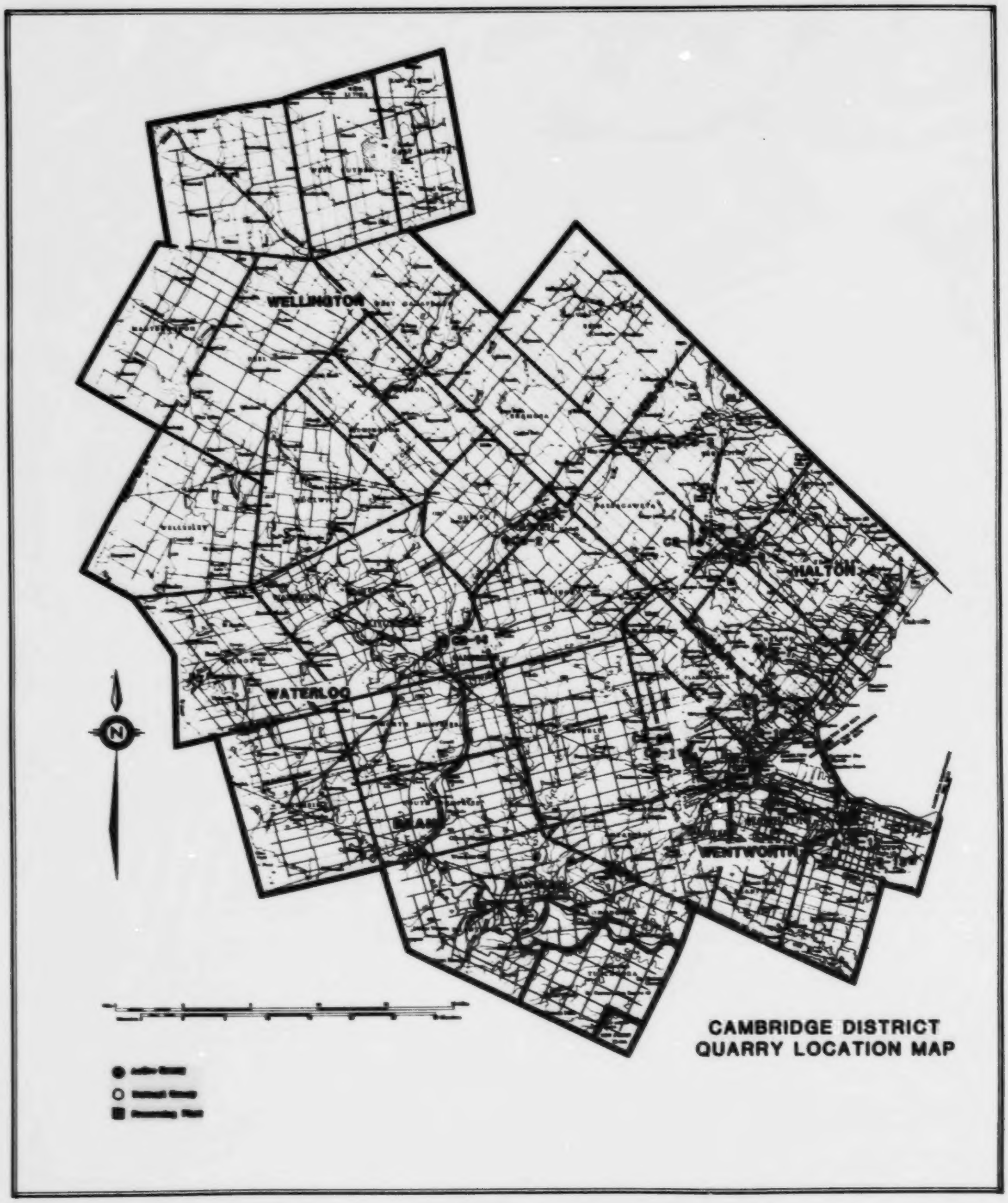

WELLINGTON
WATERLOO
HALTON
WENTWORTH
N
CAMBRIDGE DISTRICT
QUARRY LOCATION MAP

Figure CB-0-1. CAMBRIDGE DISTRICT QUARRY LOCATION MAP.

a brown, fine– to coarse–crystalline fossiliferous dolostone. This is similar to the Fossil Hill Formation, the approximate stratigraphic equivalent found on the Bruce Peninsula. The Reynales is seen in both active and abandoned quarries where excavations were deepened for the emplacement of sumps. The abandoned Clappison's Corners (CB–10) and Old Nelson (CB–8) quarries expose sections through the Reynales, Irondequoit, Rochester and Lockport/Amabel Formations.

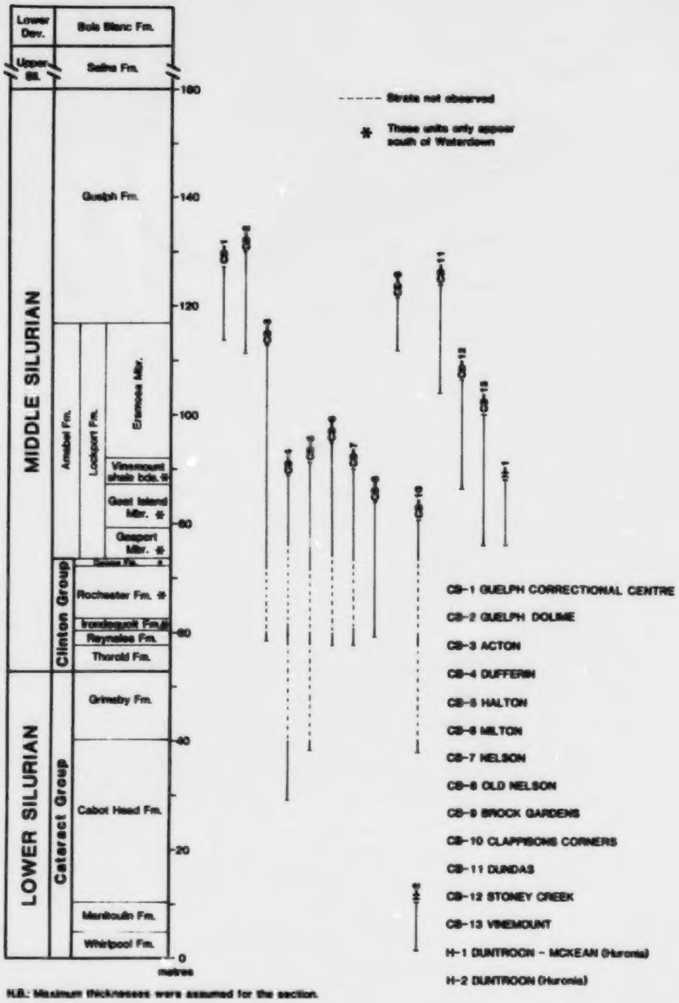

Lower Dev.
Bois Blanc Fm.
Upper Sil.
Salina Fm.
MIDDLE SILURIAN
LOWER SILURIAN
Guelph Fm.
Amabel Fm.
Lockport Fm.
Eramosa Mbr.
Vinemount shale bds. *
Goat Island Mbr. *
Gasport Mbr. *
Clinton Group
Rochester Fm. *
Irondequoit Fm.
Reynales Fm.
Thorold Fm.
Cataract Group
Grimsby Fm.
Cabot Head Fm.
Manitoulin Fm.
Whirlpool Fm.
160
140
120
100
80
60
40
20
0
metres
N.B.: Maximum thicknesses were assumed for the section.
----- Strata not observed
* These units only appear south of Waterdown
CB-1 GUELPH CORRECTIONAL CENTRE
CB-2 GUELPH DOLIME
CB-3 ACTON
CB-4 DUFFERIN
CB-5 HALTON
CB-6 MILTON
CB-7 NELSON
CB-8 OLD NELSON
CB-9 BROCK GARDENS
CB-10 CLAPPISONS CORNERS
CB-11 DUNDAS
CB-12 STONEY CREEK
CB-13 VINEMOUNT
H-1 DUNTROON - MCKEAN (Huronia)
H-2 DUNTROON (Huronia)

**Figure CB-0-2. STRATIGRAPHIC COLUMN SHOWING PRINCIPAL QUARRIES OF CAMBRIDGE DISTRICT.**

Sharply and conformably overlying the Clinton Group are the Lockport and Amabel Formations. From Niagara Falls to Waterdown (north of Hamilton), the Lockport Formation can be subdivided into three members (in ascending order); the Gasport, Goat Island and the Eramosa. These rocks consist of fossiliferous dolostones, very fine-crystalline cherty dolostones, argillaceous dolostones with shaly partings and dark grey-brown, bituminous, very fine-crystalline dolostones. In the southwestern area of this district, the Vinemount shale beds are found near the base of the Eramosa Member. The sequence is well exposed at the Vinemount Quarry (CB-13). Also, good outcrop exposures of the Lockport Formation occur in road-cuts along Highway 20 at Stoney Creek, and Highway 403 in Hamilton. The Flamboro Quarries Ltd. (CB-9), Dundas (CB-11), Vinemount (CB-13), and Stoney Creek (CB-12) quarries are the only active quarries in the district utilizing the Lockport Formation.

North of Waterdown, a significant facies change occurs in the well-bedded dolostones, limestones and shales of the Irondequoit to Goat Island sequence. These rocks are replaced by the Amabel Formation, which consists of an irregular, massive- or thick-bedded, medium- to coarse-crystalline dolostone, characterized by reefal or biohermal massive-bedded structures. The Old Nelson Quarry (CB-8) provides the most southerly exposure of the Amabel Formation. The Eramosa Member exists as the uppermost unit in the Lockport Formation to the south and the Amabel Formation to the north. Most of the quarries in the Cambridge District (see Figure CB–0–2) have targeted the Amabel and Lockport Formations for their operations. The maximum thickness in the district for the Amabel is 40 m in the Acton Quarry (CB–3).

Overlying the Eramosa Member is the Middle Silurian Guelph Formation, a medium– to massive–bedded, sucrosic dolostone. Outcrops are numerous and occur along the Grand River gorge between Fergus and Elora, in the vicinity of Troy and Rockton, in the former towns of Galt and Preston (along the Grand River), and around Hayesland and Glenchristie. The underlying contact with the Eramosa Member is sharp and disconformable at the abandoned Guelph Correctional Centre Quarry (CB–1), whereas at the active Guelph Dolime (CB–2) and Stoney Creek (CB–11) Quarries, the contact is transitional. One other quarry, the Flamboro Quarries Ltd. Quarry (CB–9), presently extracts the Guelph Formation which is also exposed by numerous abandoned quarries in the district.

The overlying Upper Silurian Salina Formation, a grey shale and argillaceous dolostone with abundant gypsum seams, is located in the subsurface and outcrops along the Nith and Grand Rivers near Paris, and around Caledonia. Occurring in the southwest corner of the district are the Upper Silurian Bass Islands Formation, a fine–crystalline dolostone, and the youngest Paleozoic unit of the district, the Lower Devonian Bois Blanc Formation, which is a cherty, fossiliferous bioclastic, argillaceous limestone. Both these formations only exist in the subsurface.

All operating quarries in the Cambridge District utilize material from either the Amabel and Lockport Formations or the Guelph Formation for road construction, asphalt, concrete aggregate and crushed stone, except for the Guelph Dolime Quarry (CB–2) where high purity dolostones of the Guelph Formation are extracted for the manufacture of dolomitic lime, and the Dundas Quarry (CB–11) where Guelph and Lockport (Eramosa) dolostones are extracted for aggregates and dolomitic lime.

## LIMESTONE INDUSTRIES

The principal limestone products in the Cambridge District are construction aggregate and lime–metallurgical–chemical stone. Stone production in 1986 for the district exceeded 17,000,000 tonnes and was principally used in the construction industry as road and concrete/asphalt aggregate and for the production of lime.

Approximately 13,400,000 tonnes were produced in the Regional Municipality of Halton and includes production from United Aggregates Ltd. – Acton Quarry (CB–3), Dufferin Aggregates – Milton (Dufferin) Quarry (CB–4), Halton Crushed Stone Ltd. – Halton Quarry (CB–5), Milton Limestone –Milton Quarry (CB–6) and Nelson Aggregate Co. – Nelson Quarry (CB–7).

Production from the Regional Municipality of Hamilton–Wentworth is a distant second at approximately 3,400,000 tonnes principally derived from Flamboro Quarries Ltd. (CB–9), Steetley Lime and Aggregates Division – Dundas Quarry (CB–11), Taro Aggregates – Stoney Creek Quarries (CB–12), and Waterford Sand and Gravel – Vinemount Quarry (CB–13). The balance of the production is derived from Wellington County principally from Guelph Dolime Ltd. – Quarry and Lime Plants (CB–2).

Lime production, in 1986, for the district is reported to be over 274,000 tonnes and includes production from Guelph Dolime Ltd. (CB–2) and Steetley Lime and Aggregates Division (CB–11) (Ontario Mineral Score, 1987).

## CB–1 GUELPH CORRECTIONAL CENTRE QUARRY

### LOCATION AND OWNERSHIP

This abandoned quarry is located on the property of the Guelph Correctional Centre (Figure CB–1–1).

### GEOLOGY

The quarry face exposes the contact between the thin–bedded, brown–black, highly bituminous dolostone and arenaceous dolostone of the Eramosa Member (Amabel Formation) and the Guelph Formation (Middle Silurian). The Guelph is a brown, massive fine– to medium–crystalline, vuggy, fossiliferous dolostone. It has a petroliferous odor and in places is reefy. Fossils found include ostracods, brachiopods, corals and shell frag-

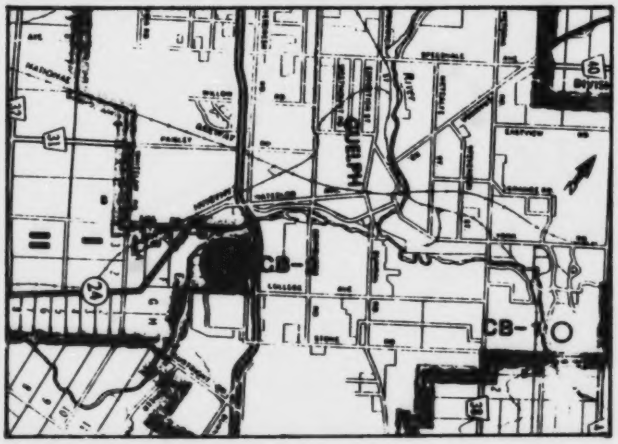


Figure CB–1–1. LOCATION MAP FOR GUELPH CORRECTIONAL CENTRE QUARRY.

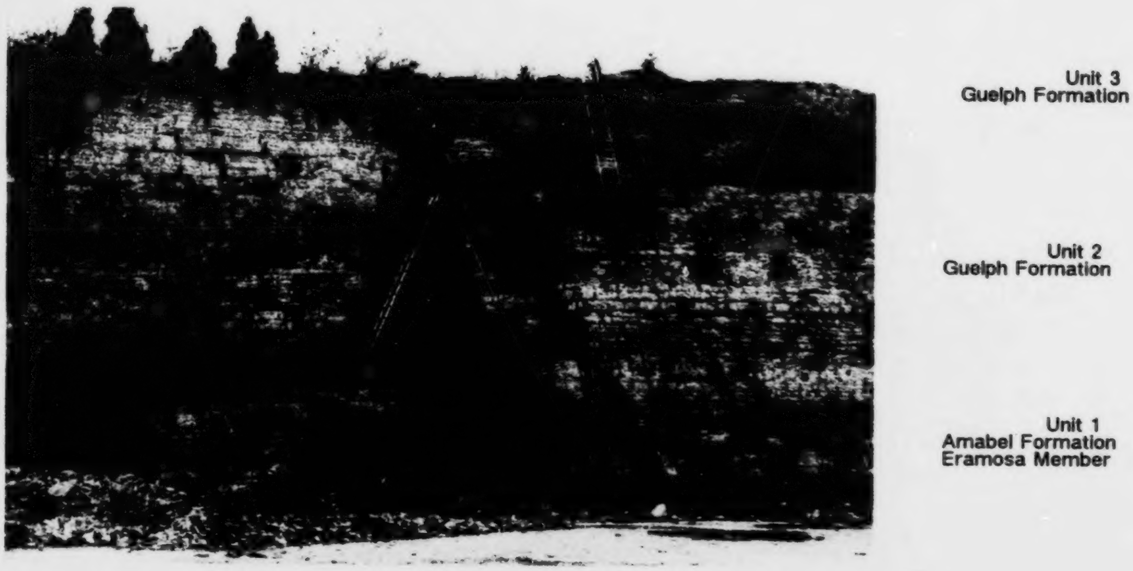

Unit 3
Guelph Formation
Unit 2
Guelph Formation
Unit 1
Amabel Formation
Eramosa Member

Photo CB-1-1. GUELPH AND AMABEL FORMATIONS IN THE NOW ABANDONED GUELPH CORRECTIONAL CENTRE QUARRY.

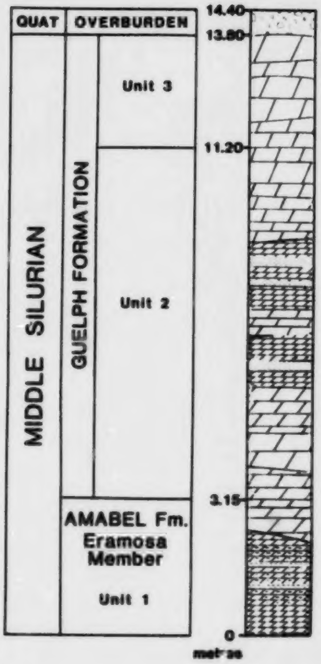

QUAT
OVERBURDEN
MIDDLE SILURIAN
GUELPH FORMATION
Unit 3
Unit 2
AMABEL Fm.
Eramosa
Member
Unit 1
14.40
13.80
11.20
3.15
0
metres

Figure CB-1-2. STRATIGRAPHIC COLUMN FOR GUELPH CORRECTIONAL CENTRE QUARRY.

ments. Abundant conulariids (some up to 17 cm long) were found on the quarry floor. In total, 13.8 m of strata are exposed (Figure CB–1–2).

### Geological Section

*Thickness*

*UNIT 3 Guelph Formation* *2.6m*

Dolostone: light brown to buff, weathers same; fine to medium crystalline, coarse crystalline in fossil zones; medium to thick bedded, sharp contacts, undulatory; porous, vuggy; abundant reefal debris (crinoids, solitary corals, brachiopods); gradational lower contact.

*UNIT 2 Guelph Formation* *8.05m*

Dolostone with shaly partings: light brown to black, weathers buff to light grey; fine crystalline; variable bedding (0.05 to 1.0 m), irregular contacts with shaly partings; black to cream coloured chert nodules, iron staining on shale beds, sphalerite and calcite crystals; shale partings display ostracods, brachiopods, trilobite fragments, bryozoa and lenses of bitumen filled corals; lower contact is sharp.

*UNIT 1 Amabel Formation, Eramosa Member* *3.15m*

Dolostone: black to light brown, weathers blue-grey, shaly, fine to medium crystalline; thin to medium bedded (2 to 35 cm); sharp contacts, undulatory bedding with shaly partings; chert nodules occur in lenses which contain abundant fossil material, calcite and sulphide mineralization are also present, large conulariids (up to 17 cm long) are present along bedding planes in the quarry floor.

*Total thickness* *13.8m*

### REFERENCES

Goudge, 1938, p. 292–293

Caley, 1941a, pp. 25, 64
ARIP 88, 1985, p. 20

### MAPS

Caley, 1941d, GSC Map 624A
Telford, 1976b, ODM Map 2342

## CB-2 GUELPH DOLIME LTD. — QUARRY AND LIME PLANT

### LOCATION AND OWNERSHIP

Guelph DoLime Ltd., a subsidiary of Dofasco Inc., operates a quarry and dolomitic lime plant on the east side of Highway 24, east of the Speed River, on the southwest fringe of the City of Guelph (Figure CB-2-1). The property comprises parts of Lots 1 to 5 in Concessions 4 and 5, Division G, in the Township of Guelph, County of Wellington.

The company has provided the following chronological list of events in the 155 year history (to 1987) of this property:

1832 –Property owned by a Mr. Wingfield.

1837 –John Howitt acquired 320 ha.

1872 –Father Hamel worked what was then known as the Priest Quarters.

1880 –1900 – George Kennedy operated the quarry

1902 –Quarry operated by Father Doyle prior to its sale to the Christie–Henderson Company.

1906 –Steam boiler installed for power supply.

1907 –First hydrate produced.

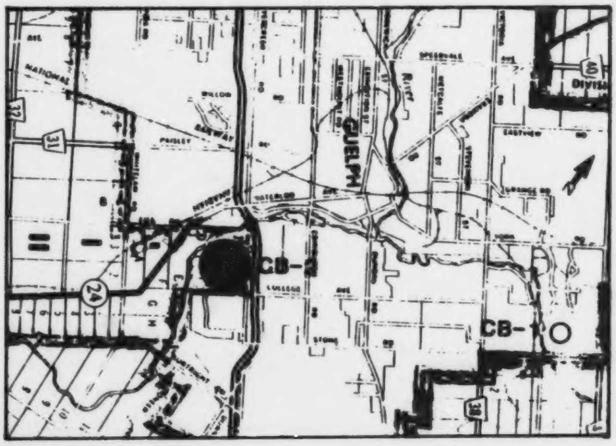


**Figure CB-2-1. LOCATION MAP FOR GUELPH QUARRY.**

1911 –Steam introduced into kilns.

1912 –Electricity brought to plant.

1914 –Company merged into Standard White Lime Company.

1924 –First steel–shelled kilns installed.

1925 –Mill destroyed by fire, and rebuilt.

1927 –Sixty–five people employed, working the quarry by hand and loading the kilns manually. The process included a two–cycle hydrator and Raymond mill and the kilns were fired by wood.

1931 –Only thirty employed due to reduced market accompanying the depression. Operation purchased by Canadian Gypsum Company on April 1st. Wages were 35¢ per hour. Plant capacity was 40 tonnes per day using five kilns.

1941 –Plant capacity increased to 86 tonnes per day using eight kilns.

1952 –Three new kilns added.

1954 –One new kiln added.

1959 –Two new kilns added.

1978 –Operation purchased by BeachviLime (Dofasco) on March 1st.

1979 –Installation of forced air fans on twelve kilns increased production from 225 tonnes to 340 tonnes per day. Work force increased to 62.

1980 –New screening plants installed. One kiln automated to continuous production. Replaced an apron feeder with a vibrating feeder. Installed a second pan conveyor in the grinding room. New power house constructed.

1982–1983 – Installed new Pay conveyor system in the lime plant.

1985 –Replaced the stone conveyor system from the primary crusher to the kilns.

1986 –Plant capacity increased to 360 tonnes per day using 10 kilns. Work force comprised 45 hourly workers and 8–10 salaried staff.

1987 –New emission control systems planned for the lime kilns.

Guelph Dolime Ltd. also own a quarry and lime plant located in Lots 1, 2 and 3, Concession 4, Puslinch Township. This property has been inactive for several years but was previously operated by Domtar Inc. A description of the quarry geology and plant is found in Hewitt, 1960, p. 123.

### Geology

Two lifts are present, which expose some 16 m of Middle Silurian Guelph Formation, and about 3 m of Amabel Formation (Figure CB-2-2). The Amabel Formation

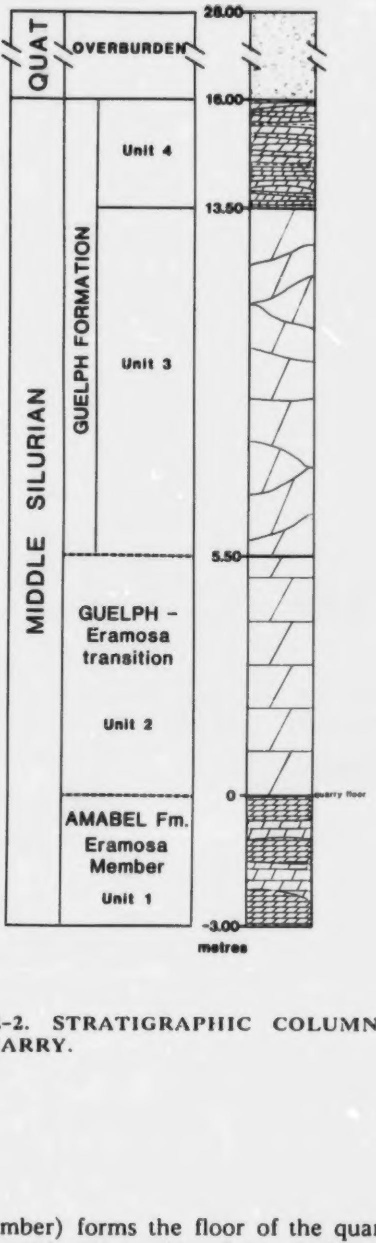


Figure CB-2-2. STRATIGRAPHIC COLUMN FOR GUELPH QUARRY.

(Eramosa Member) forms the floor of the quarry (exposed in the sump) and consists of thin-bedded bituminous dolostone. This rock is coarse crystalline and dark brown. Overlying this are 5.5 m of transitional Eramosa-Guelph Formation dolostones. They are typically grey-green, medium-crystalline, massive, fossiliferous dolostones which are less bituminous than the underlying rocks. These rocks are overlain by a pure, white to buff in colour, fine- to medium-crystalline, massive and thin-bedded dolostone, of the Guelph Formation. Overburden, consisting largely of coarse sand, is 8 m to 12 m thick.

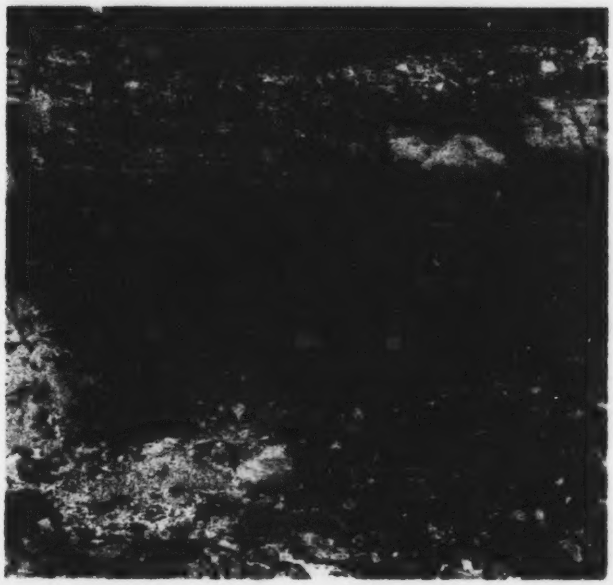


Photo CB-2-1. UPPER SECTION OF THE EXPOSED GUELPH FORMATION IN THE GUELPH DOLIME QUARRY.

## Geological Section

*Thickness*

*UNIT 4 Guelph Formation* *2.5m*

Dolostone: white-buff, weathers light buff; fine to medium crystalline; thin bedded (4 to 20 cm), contacts are irregular and undulatory; fossil debris in bands, rare gastropods; minor shaly laminae; lower contact is gradational.

*UNIT 3 Guelph Formation* *8.0m*

Dolostone: white, weathers light buff; fine crystalline; massive with draping structures that pinch and swell; calcite crystals in vugs; pelecypods, gastropods and stromatoporoids are present and can occur abundantly in some zones as reefal debris; lower contact is gradational.

*UNIT 2 Guelph and Amabel Formation,*
*(Eramosa Member) Transition* *5.5m*

Dolostone: light grey, weathers green-grey; medium crystalline; massive bedding; calcite crystals in vugs; fossils present include abundant stromatoporoids and algal rip-ups, rare corals, gastropods and bryozoa; strong bituminous odour on fresh surface; the lower half of this unit is darker in colour than the overlying half; reefal in places; lower contact is gradational.

*UNIT 1 Amabel Formation, Eramosa Member* *3.0m*

Dolostone: dark brown, weathers light brown; coarse crystalline; thin to medium bedded (5 to 55 cm), sharp undulatory contacts; calcite, pyrite and sphalerite present; very petroliferous odour on fresh surface; stylolites present.

*Total thickness* *19.0m*

### QUARRY OPERATION

The Guelph Quarry is located east of the plant and occupies about half of the 100 ha property. Quarry production averages 125 tonnes per hour.

Overburden is removed by front end loader and trucks. A 19 m section of dolostone is worked in two lifts. Drilling is accomplished with an Ingersoll–Rand wagon drill equipped with a 7.5 cm bit. Holes are spaced on a 3 m square grid pattern. Dynamite and prilled ammonium nitrate are the blasting agents. A 5–yd P&H electric shovel loads two 25–ton Terex trucks for delivery to the primary crusher.

### PROCESSING

The –12 in. crusher discharge is conveyed to a surge pile and reclaimed by conveyor to a double–deck scalping screen with 3 1/2 in. and 1 1/2 in. openings. The oversize stone (3 1/2 in. to 12 in.) is kiln–feed for the ten vertical stack kilns now in use. These are gas–fired and have a total capacity of 360 tonnes per day.

The –3 1/2 in. stone is screened into various products for construction aggregate, agricultural dolostone, and flux for steel making. Calcined stone is also used for steel making and for fibreglass in lump or pebble form. Finer calcined products are used as masons, finishing or industrial quicklime and further grindings results in superfine products for the same markets.

Some of the crushed calcined lime is combined with a measured amount of water in a hydrator to produce hydrated lime. Further grinding and air separation produces a range of hydrated products for masonry and finishing purposes, and for agricultural and industrial uses.

### PRODUCTS

#### Raw Stone:

Agricultural dolostone
Construction aggregate
Industrial stone (steel industry)

#### Calcined Stone

Lump or pebble (fibreglass and steel industry)
Masons lime
Finishing lime
Industrial quicklime

#### Hydrated Stone

Masons hydrated lime
Finishing hydrated lime
Agricultural hydrated lime
Industrial hydrated lime

### REFERENCES

Goudge, 1938, p. 291–292
Hewitt, 1960, p.124
Hewitt, 1964a, p.57
Vos, 1969, p. 50
Hewitt and Vos, 1972, p. 49
ARIP 88, 1985, p. 20
Sabina, 1986, p. 130

### MAPS

Caley, 1941d, GSC Map 624a
Telford, 1976b, ODM Map 2342

## CB-3 UNITED AGGREGATES LTD. – ACTON QUARRY

### LOCATION AND OWNERSHIP

This quarry is one of the largest in Ontario and is located on the brow of the Niagara Escarpment, 2 km east of Acton in Lots 21 to 24, Concessions 3 and 4, Town of Halton Hills (formerly Esquesing Township) Regional Municipality of Halton (Figure CB–3–1). The Acton Quarry dates back to the turn of the century and until 1930 was operated for the production of dolomitic lime by the Toronto Lime Company. The quarry was reopened in 1963 by Acton Limestone Quarries Ltd. From 1967 to 1985 the quarry was operated by Indusmin Ltd. and was purchased in June of 1985 by the present owner and operator, United Aggregates Ltd. The quarry licence covers an area of 232.88 ha.

### GEOLOGY

The quarry exposes over 40 m of Middle Silurian dolostones of the Amabel and Reynales Formations (Figure CB–3–2).

The section presents a sequence of massive, lenticular and thinner–bedded interlenticular strata of the

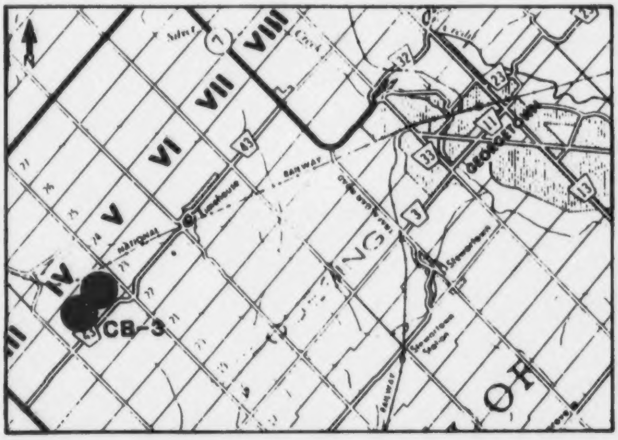


Figure CB-3-1. LOCATION MAP FOR ACTON QUARRY.

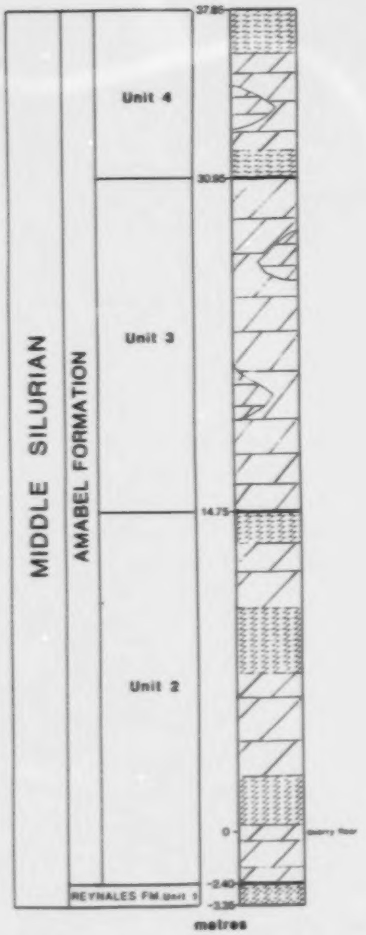


**Figure CB-3-2. STRATIGRAPHIC COLUMN FOR ACTON QUARRY.**

Amabel Formation, overlying 0.95 m of thin-bedded dolostones of the Reynales Formation. The rocks are mostly medium to coarse crystalline, cream grey and richly fossiliferous. The bedrock surface is locally irregular, and good reef flanks are evident in some parts of the quarry. Overburden averages about 2.5 m in thickness.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 4 Amabel Formation* | *6.9m* |
| Dolostone: cream white-buff, weathers buff; fine to coarse crystalline; both massive, lenticular and thin bedded (0.2 to 1.0 m), contacts pinch and swell and are undulatory; calcite crystals in fossil molds; richly fossiliferous with crinoids, brachiopods, bryozoans and gastropods; some draping occurs, gradational lower contact. | |
| *UNIT 3 Amabel Formation* | *16.20m* |
| Dolostone: white-grey, weathers white-buff, medium crystalline; massive bedded, sharp irregular contacts; calcite in vugs (5 by 10 cm); abundant crinoids; abundant grey bands and styolites; porous; some draping present; gradational lower contact (colour change). | |
| *UNIT 2 Amabel Formation* | *17.15m* |
| Dolostone: grey to brown-grey, weathers grey; fine to coarse crystalline; thin to massive bedded (0.15 to 1.5 m), irregular contacts with clay partings; calcite in vugs and sphalerite in lenses; abundant crinoids and rare brachiopods; porous; large reefal masses which drape over from Unit 3; grey colour banding present; sharp lower contact due to colour change. | |
| *UNIT 1 Reynales Formation* | *0.95m* |
| Dolostone: dark green-grey, weathers same; fine crystalline; thin bedded (4 to 7 cm), undulatory contacts; interbedded with shale; fossil trails present; lower contact is water covered. | |
| *Total thickness* | *41.2m* |

## QUARRY OPERATION

The quarry operates 12 months a year and is presently worked on two lifts. The 15 m face being worked to the north and east represents the second or lower lift, and the 26 m face being worked to the south and west is the combination of the second lift and the original 11 m upper lift. The 15 m face is advancing towards the processing plant. The blasted stone is loaded by a Cat 992C 13.8 yd. loader into two Euclid B85 (85-ton) trucks and/or two Euclid R50 (50-ton) trucks and is currently hauled approximately 1.7 km to the primary crusher feed hopper. Ramp design alterations are planned that would reduce the haulage distance to about 1 km.

A drilling pattern of 7 m x 7.6 m is used; 25 cm diameter holes are drilled to 0.9 m subgrade with a Bucyrus-Erie 50R rotary drill. The blast holes are loaded with bulk aluminized AN/FO and straight AN/FO, leaving a 4 m collar. The holes are initiated top and bottom by non-electric delay caps, and 1lb. primers are used. Blasting occurs twice a week and is monitored for vibrations.

## PROCESSING

The plant capacity is in excess of 2.5 million tonnes of crushed aggregate annually. The process flow sheet for the plant is shown on Figure CB-3-3.

The blasted stone can be dumped either directly into the primary feed hopper, or onto a double deck grizzly that produces riprap stone and feeds the finer materials to the primary crusher.

The primary crusher is a 54 in. x 74 in. Allis-Chalmers jaw, producing -9 in. material that is conveyed to a surge pile. Three Syntron feeders recover the stone from the surge pile and convey it to a 5 in. scalping screen. This screen routes +5 in. material to a Telsmith F66 cone crusher, the product going to a triple deck Vibra King screen. Plus 7/8 in. oversize is sent to a second Telsmith

**Photo CB-3-1.**
**FACE AT ACTON QUARRY, SHOWING MASSIVE, LENTICULAR REEFAL STRUCTURES (RIGHT, TOP) AND THINNER-BEDDED, FLANKING STRATA (LEFT, BOTTOM).**

**Photo CB-3-2. BUCYRUS-ERIE 50R ROTARY DRILL ON LIFT 2 AT ACTON QUARRY (LOOKING NORTHEAST).**

**Photo CB-3-3. PROCESSING CONTROL TOWERS AT ACTON QUARRY (LOOKING NORTHEAST).**

F66 cone crusher and −7/8 in. material is sent to a 6 ft. x 20 ft. Hewitt–Robins double deck screen. The −5 in. material that passed the scalping screen is sent to two double deck Vibra King screens that add −7/8 in. material to the Hewitt–Robins screen and send +7/8 in. oversize to a Hazemag CHOV/K impact crusher. The Hewitt–Robins screen produces −1/4 in. fines that go to a 70–tonne truck loadout bin and −7/8 in. + 3/16 in. stone that is stockpiled.

Material leaving the second Telsmith and the Hazemag crushers (−2 1/2 in.) is carried by a conveyor to the first control tower, where the stone is sent to two 5 ft. x 16 ft. Vibra King triple deck screens. From these screens, +2 in. oversize is returned to the second Telsmith cone for recrushing; −2 in. + 7/8 in. is sent to a surge bin or directly to a stockpile; −7/8 in. is sent to a surge bin or directly to a stockpile; −7/8 in. + 1/4 in. is sent to the second control tower or a stockpile; and −1/4

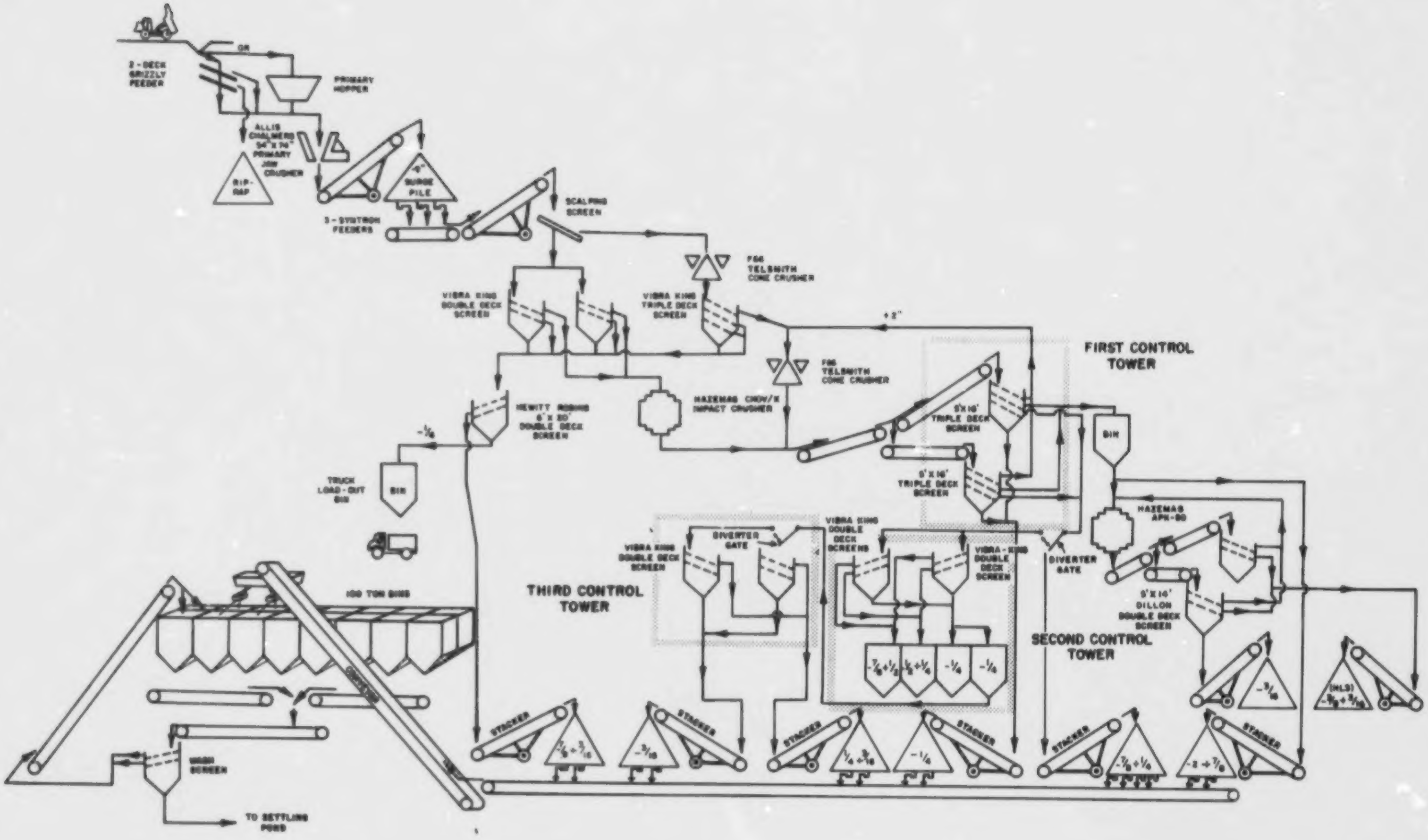

2-DECK GRIZZLY FEEDER
OR
PRIMARY HOPPER
ALLIS CHALMERS 36" X 74" PRIMARY JAW CRUSHER
RIP-RAP
-6" SURGE PILE
3-SYNTRON FEEDERS
SCALPING SCREEN
F66 TELSMITH CONE CRUSHER
VIBRA KING DOUBLE DECK SCREEN
VIBRA KING TRIPLE DECK SCREEN
+2"
F66 TELSMITH CONE CRUSHER
HAZEMAG CMOW/K IMPACT CRUSHER
HEWITT ROBINS 6' X 20' DOUBLE DECK SCREEN
-1/4
TRUCK LOAD-OUT BIN
BIN
FIRST CONTROL TOWER
5'X16' TRIPLE DECK SCREEN
5'X16' TRIPLE DECK SCREEN
BIN
HAZEMAG APK-60
DIVERTER GATE
5'X14' DILLON DOUBLE DECK SCREEN
SECOND CONTROL TOWER
VIBRA KING DOUBLE DECK SCREENS
VIBRA-KING DOUBLE DECK SCREEN
-7/8+1/2
1/2+1/4
-1/4
-1/4
VIBRA KING DOUBLE DECK SCREEN
DIVERTER GATE
THIRD CONTROL TOWER
100 TON BINS
WASH SCREEN
TO SETTLING POND
STACKER
-7/8 + 3/16
-3/16
STACKER
STACKER
1/4 + 3/16
-1/4
STACKER
STACKER
-7/8 + 1/4
-2 + 7/8
STACKER
-3/16
(HL3) -3/8 + 3/16

Figure CB-3-3. PROCESS FLOW SHEET FOR ACTON QUARRY.

in. fines are sent to a stockpile. In the second control tower, two Vibra King double deck screens separate −7/8 in. + 1/2 in. and −1/2 in. +1/4 in. fines that are sent to the third control tower. In the third tower, two Vibra King double deck screens produce −1/4 in. +3/16 in. and −3/16 in. material.

The −2 in. + 7/8 in. stone from the first tower can be sent from the surge bin for tertiary crushing by a Hazemag APK−50 impeller crusher, and screening by two double deck Dillon screens, one 6 ft. x 16 ft. and the other 5 ft. x 14 ft. These screens produce −3/8 in. + 3/16 in. (HL3) and −3/16 in. fines.

A 42 in. reclaiming conveyor is installed in a tunnel beneath the 50,000 tonne stockpiles and is supplied by Syntron feeders. The stone can be automatically blended and conveyed for storage in sixteen 100−tonne bins. Stone from any of these bins can be sent to the washing plant and returned to the appropriate bin. All product shipping is by truck though rail facilities do exist at the site.

### PRODUCTS

Armour Stone
Riprap 12 in. x 24 in.
Riprap 10 in. x 12 in.
Gabion Stone 4 in. x 8 in.
Gabion Stone 3 in. x 5 in.
2 in. Crusher Run
3/4 in. Crusher Run
Granular "A"
2 in. Clear
1 1/2 in. Clear
7/8 in. Clear
1/4 in. Screenings
3/16 in. Screenings
HL8
HL3

### REFERENCES

Goudge, 1938, p. 237−238
Caley, 1940, p. 103
Hewitt, 1964a, p. 53−55
Vos, 1969, p. 46−47
Hewitt and Vos, 1972, p. 50−51
ARIP 46, 1983, p. 14
Sabina, 1986, p. 130−131

### MAPS

Caley, 1941d, GSC Map 624A
Telford, 1976b, ODM Map 2342
Bond et al., 1976, ODM Map 2337

## CB−4 DUFFERIN AGGREGATES − MILTON (DUFFERIN) QUARRY

### LOCATION AND OWNERSHIP

The Milton Quarry, owned and operated by Dufferin Aggregates, a division of St. Lawrence Cement Inc., is located 4 km northwest of Milton in the Towns of Halton Hills and Milton, Regional Municipality of Halton (Figure CB−4−1). The quarry opened in 1962 at the base of the Escarpment. In 1975 the new plant started producing aggregates in its present location. The site of the old plant has been rehabilitated and now provides a park−like setting for an employee "chalet", baseball diamonds and a small trout pond. The Milton quarry has the largest production in Ontario and operates year−round.

The highly automated crushed stone plant is the largest in Ontario and has a capacity of 2,000 tonnes per hour through the primary crusher and the truck loadout system. The quarry licence covers an area of 434.87 ha.

### GEOLOGY

The 15.8 m deep Milton Quarry exposes coarse−crystalline, grey−buff, thick− to massive−bedded and fossiliferous dolostones of the Middle Silurian Amabel Formation. Below the quarry floor, argillaceous units are exposed in a crusher pit. They include 4.0 m of the Reynales Formation, a dolostone with shaly partings, and 11.0 m of the Cabot Head Formation, a red and green shaly dolostone. In total, 34.8 m of section are exposed in the quarry (Figure CB−4−2). Overburden averages 1.5 m in thickness.

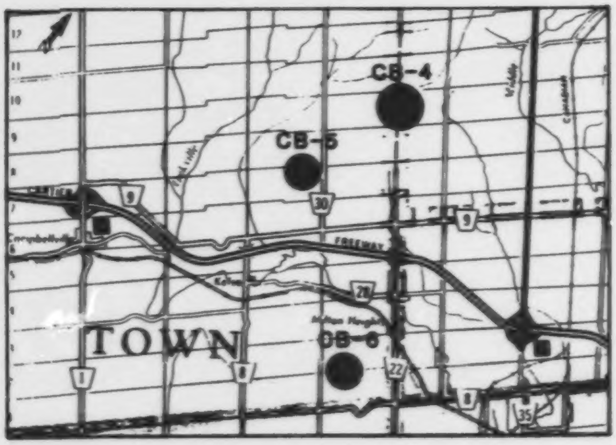


Figure CB−4−1. LOCATION MAP FOR MILTON (DUFFERIN) QUARRY.

### Geological Section

*Thickness*

*UNIT 4 Amabel Formation 6.8m*

Dolostone: cream to light grey, weathers buff to light brown; coarse to very coarse crystalline; thin bedded, sharp, slightly irregular contacts; calcite and dolomite crystals in vugs; abundant reefal debris, very fossiliferous (large crinoids, brachiopods, gastropods, and solitary corals); sharp, undulatory lower contact.

*UNIT 3 Amabel Formation 9.0m*

Dolostone: cream, weathers buff-grey; coarse to very coarse crystalline; massive, undulatory bedding; very porous with calcite and dolomite crystals in vugs; very fossiliferous (same as unit 4); hummocky quarry floor is lower contact.

*UNIT 2 Reynales Formation 4.0m*

Dolostone with shaly partings: green-blue to grey, weathers buff-brown; fine crystalline; thin bedded, contacts are sharp with shaly partings and are bioturbated; unit grades to a shalier and thinner dolostone down section; faint dark laminations; calcite and dolomite in vugs, pyrite in fossil molds; abundant fossil fragments; lower contact is sharp.

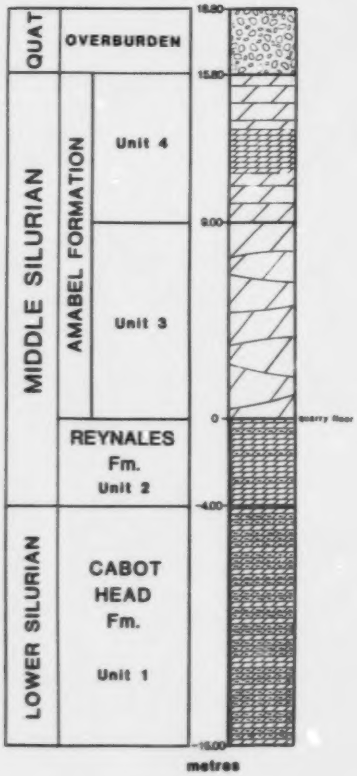


Figure CB-4-2. STRATIGRAPHIC COLUMN FOR MILTON (DUFFERIN) QUARRY.

*UNIT 1 Cabot Head Formation 11.0m*

Shaly dolostone: dark red-brown, weathers red and green; fine grained; thin bedded with sharp, irregular contacts; very fossiliferous (bryozoans, brachiopod, and crinoid debris); lower contact not exposed.

*Total thickness 34.8m*

## QUARRY OPERATION

The quarry is presently excavated over an area of 130 ha, mining a single lift of 6.7 m to 24.4 m (averaging 18.3 m). The overburden is removed using two 1 1/4 yd. JD 790 backhoes and four 35-ton Euclid trucks. Drilling of the irregular, stripped surface is performed by an Ingersoll-Rand DM50 and DM4A Drillmaster, boring 200 mm diameter holes with Hughes HH44 Tri-cone bits. Holes are drilled to an average depth (depending on the face height) of 18.3 m plus 1.2 m subgrade, on a 5.8 m x 6.4 m pattern. Each hole incorporates a liner and is toe loaded with 125 kg of 10% ALAN/FO resulting in 4.6 m of column rise and the remainder is loaded with AN/FO, except for a 3.7 m collar. A Noner bottom hole primer extends to the toe and is initiated at the top by a Noner ms connector. An average shot of about 20 holes in a single row breaks about 32,000 tonnes of rock. Every shot is recorded on a OZA INSTATEL seismograph. Blasted stone is loaded by a 17 yd. RH 120C hydraulic excavator into five 85-ton Terex 33-11B trucks for haulage to the primary crusher (approximately 600 m). The O & K excavator is assisted by a Cat 992B (10 yd.) loader for clean up after blasting, handling oversize and occasionally loading trucks.

### Mobile Equipment

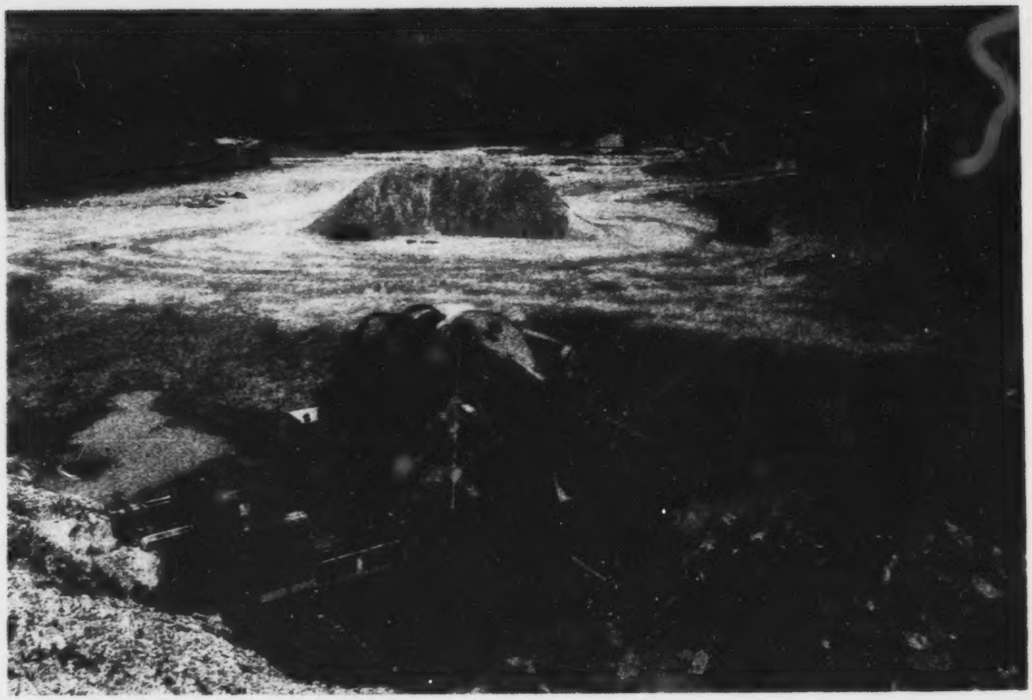
| | |
|---|---|
| Clearing – | contract cutting |
| Stripping – | 2 – John Deere 1 1/4 yd.<br>4 – 35-ton Haulage trucks |
| Drilling – | 1 – Ingersoll-Rand DM50 Drillmaster Rotary Drill<br>1 – Ingersoll-Rand DM4A Drillmaster Rotary Drill |
| Loading – | 2 – Caterpillar 992B Loaders – 10 cu. yd. |
| Excavator – | 1 – 17 cu. yd. RH 120C O & K |
| Pit Hauling – | 6 – 85-ton Terex 33-11B Haulage Trucks |
| Stockpiling – | 2 – 50-ton Euclid Haulage Truck<br>3 – 35-ton Euclid Haulage Trucks |
| Shipping – | 2 – Fiat-Allis 945B Loaders – 6 cu. yd.<br>6 – Fiat-Allis FR35 Loaders |

## PROCESSING

The process flow sheet for the plant is illustrated on Figure CB-4-3.

The haulage trucks dump their loads from two sides into a 36 ft. x 45. ft. ground level feed hopper of the 54 in. x 74 in. Allis-Chalmers primary gyratory crusher. An Erie Strayer rock grapple, operated from a Demag 15-ton bridge crane, is used for positioning large rock. Material passing through the crusher enters a feed bin

**Photo CB-4-1. O & K (17 YD.) HYDRAULIC EXCAVATOR LOADING 85-TON TEREX TRUCK AT THE WORKNG FACE OF THE MILTON (DUFFERIN) QUARRY; PROCESSING FACILITY IN BACKGROUND (LOOKING NORTHEAST).**



then through a Syntron feeder and discharges on a 48 in. belt which carries the stone above ground to the 60,000 tonne surge pile.

The surge pile has a live storage capacity of 18,000 tonnes (–6 in. material), reclaimable through three Syntron feeder openings. At the secondary building the –6 in. stone is scalped on a pair of 6 ft. x 16 ft. Hewitt–Robins Vibrex double deck screens. At these screens, 4 in. to 6 in. gabion stone can be removed from the process, and the +2 1/4 in. oversize from these screens is sent to a 17 in. x 84 in. Allis–Chalmers Hydrocone secondary crusher.

The –2 1/4 in. material passing through the bottom decks of the screens is chuted to a second set of 6 ft. x 16 ft. screens in the secondary building. The –2 1/4 in. + 7/8 in. material from these screens is discharged onto a 60 in. conveyor and transferred to the classification building. The –7/8 in. material from the screens is discharged to the crusher run pile using a 24 in. stacker.

The main conveyor (60 in. wide), rated at 3,000 tonnes per hour, discharges the –2 1/4 in. stone into a hopper from which it is withdrawn by a Syntron feeder rated at 1,450 tonnes per hour to the north pair and by gravity overflow to the south pair of a bank of six 8 ft. x 20 ft. Hewitt–Robins double deck Vibrex screens. This begins two duplicate processing flows which are independent of each other.

The +2 1/4 in. oversize from these screens (originating from the 84 in. Allis–Chalmers cone) is discharged onto a 30 in. transverse conveyor and from it to a 48 in. conveyor leading back to the crusher section for feed to the tertiary crushers. The option is also available to return the 2 in. stone and 1 1/2 in. stone from the 8 ft. x 20 ft. screens for tertiary crushing. The –2 1/4 in. size from these screens continues through the mill to two banks of four 8 ft. x 20 ft. Hewitt–Robins double deck screens that produce stone sizes from +7/8 in. (1 1/2 in. stone) to –3/16 in. screenings.

Material returning for tertiary crushing is discharged into the 1,650 tonne capacity tertiary crusher feed silo, 30 m high and 12 m in diameter and of reinforced concrete construction.

Three Syntron vibrating feeders feed a pair of 5 in. x 84 in. Allis–Chalmers hydrocone crushers set at 3/4 in., and one 5 1/2 ft. Nordberg Short Head cone crusher set at 1/2 in. The material from these crushers is discharged onto the 60 in. conveyor for transport to the classification building.

Under the truck–loading bin structure are 24 air–operated bin gates, two under each side of the six major bin compartments. There are also 12 Syntron feeders, one under each side of the six major bins, for feeding single sizes or any desired blend onto two parallel loadout conveyors. Presently, one conveyor serves truck loadout and the other the two washing facilities. Loadout from stockpiles is currently handled using six Fiat–Allis FR35 6.5 cu. yd. loaders.

At present there are two wash plants on-site, both employing a wet screen and a screw dewatering system. One plant is used for the washing of concrete aggregates and the other can be used to wash concrete mix, wash 3/4 in. crusher run to upgrade it or wash 3/4 in. crusher run to separate the stone and sand fractions.

## SHIPPING

The Dufferin Aggregates plant uses an efficient computerized truck dispatching system. The tare weight of the incoming truck is taken by the computer, the dispatcher assigns the truck to a specific job on the schedule and gives his routing in the quarry via voice communications.

The computer calculates a dispatching schedule based on the order for the day. This schedule shows what kind of truck is to be sent, to what job, with what kind of aggregate and when the material is needed.

The weigh–out procedure is as follows: on command from the operator, the computer takes the weight of the truck, checks the weight against the truck's Registered Gross Weight (RGW) and, if the weight is within acceptable limits, prints a ticket automatically. The operator can then, through voice communication, tell the trucker at which station to pick up the ticket. The quarry has shipped approximately 27,000 tonnes of stone in a 12–hour day with this system.

## REHABILITATION

The mined–out areas of the quarry are currently being returned to grass and trees. Some of the overburden removed during the stripping operation is placed within the quarry, leveled and hydro–seeded with a grass mixture. Trees from local nurseries or from within the property are planted throughout the rehabilitation areas.

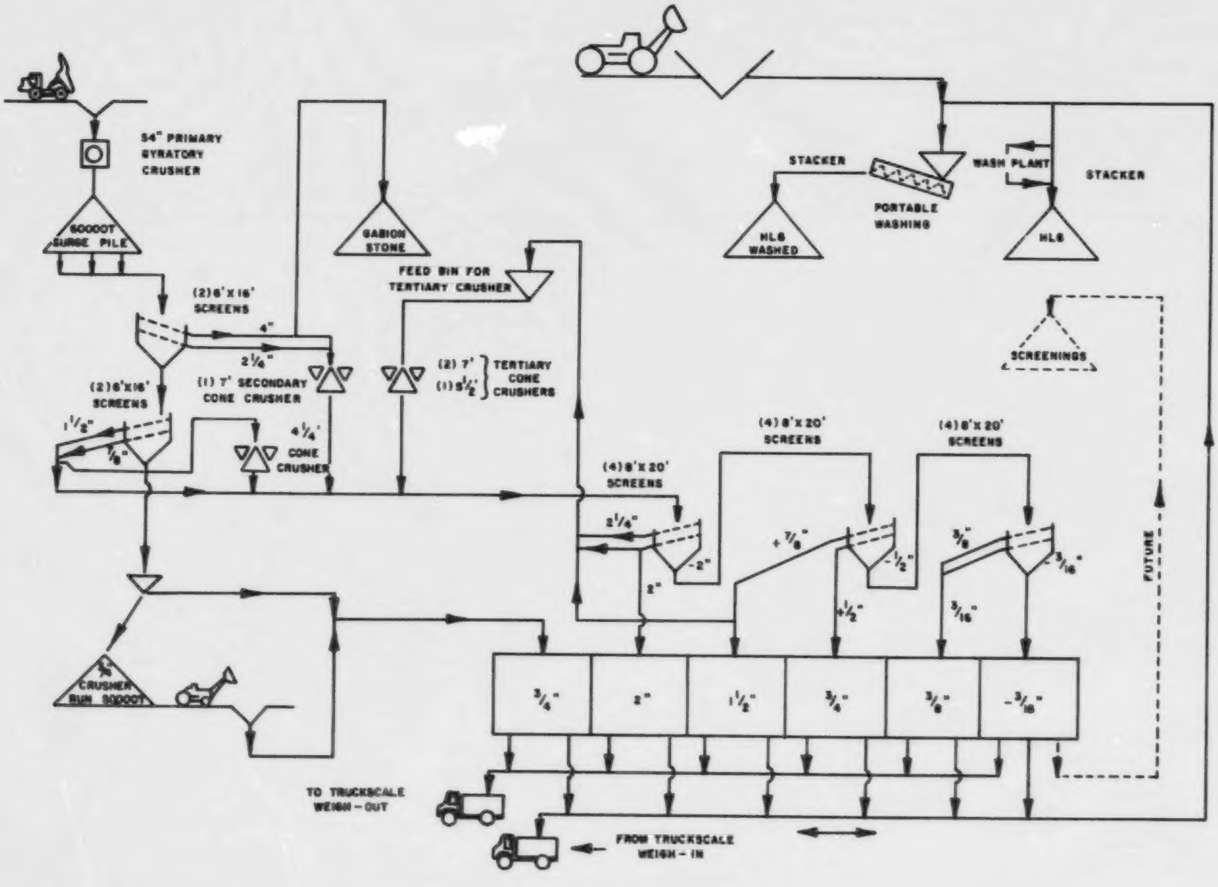

54" PRIMARY GYRATORY CRUSHER
50000T SURGE PILE
(2) 6' X 16' SCREENS
4"
2 1/4"
(1) 7' SECONDARY CONE CRUSHER
(2) 6' X 16' SCREENS
1 1/2"
7/8"
4 1/4' CONE CRUSHER
GABION STONE
FEED BIN FOR TERTIARY CRUSHER
(2) 7' (1) 5 1/2' TERTIARY CONE CRUSHERS
STACKER
PORTABLE WASHING
HL6 WASHED
WASH PLANT
STACKER
HL6
SCREENINGS
(4) 8' X 20' SCREENS
(4) 8' X 20' SCREENS
(4) 8' X 20' SCREENS
2 1/4"
-2"
2"
+ 7/8"
-1/2"
+1/2"
3/8"
-3/16"
3/16"
FUTURE
3/4" CRUSHER RUN 50000T
3/4"
2"
1 1/2"
3/4"
3/8"
-3/16"
TO TRUCKSCALE WEIGH – OUT
FROM TRUCKSCALE WEIGH – IN

Figure CB-4-3. PROCESS FLOW SHEET FOR MILTON (DUFFERIN) QUARRY.

## PRODUCTS

The following stone classifications are produced at the Dufferin Aggregates plant:

Armour Stone
4 – 6 in. Gabion Stone
3/4 in. Crusher Run
2 in. Clear
1 1/2 in. Clear
Granular A
Granular B
3/4 in. Clear Concrete Stone
3/8 in. Clear
3/16 in. Screenings
3/4 in. to 3/8 in. Blend
  Concrete Aggregates
2 in. Crusher Run

## REFERENCES

Hewitt, 1964a, p. 51–52
Vos, 1969, p. 42–43
Hewitt and Vos, 1972, p. 50
ARIP 47, 1982, p. 20
ARIP 46, 1983, p. 22
Rukavina, 1987

## MAPS

Bond et al., 1976, ODM Map 2337

# CB–5 HALTON CRUSHED STONE LTD. — HALTON QUARRY

## LOCATION AND OWNERSHIP

The Halton Quarry is located 6 km west of Milton on the brow of the Niagara Escarpment in Lots 7 and 8, Concession 6, Town of Milton (Nassagaweya Township), Regional Municipality of Halton as shown on Figure CB–5–1.

In 1985 the Halton Quarry and plant was re–acquired by Halton Crushed Stone Ltd. from Indusmin Ltd., the lessees of the property from 1970 to 1985. Production at the quarry began during the summer of 1959, primarily to supply road aggregate for local construction of Highway 401.

The quarry licence covers an area of 121.5 ha.

## GEOLOGY

The Halton Quarry exposes 21.47 m of section (Figure CB–5–2), from the Lower Silurian Cabot Head Formation to the Middle Silurian Amabel Formation. The quarry sump exposes 1 m of the Cabot Head Formation shales, which are olive green and appear to have dolomitic laminae. In the quarry floor and base of the vertical face are 2 m of the Reynales Formation, a shaly dolostone. This unit is overlain by over 20 m of massive and thin–bedded Amabel dolostone. The lower 10 m of the Amabel is banded with thin grey streaks and is fine crystalline. The overlying interval is composed of massive, lensoid beds draped with intervening thinner–bedded rocks. The Amabel Formation is richly fossiliferous, particularly in crinoidal debris. Overburden ranges from 0.25 to 4.0 m in thickness and averages 3.5 m.

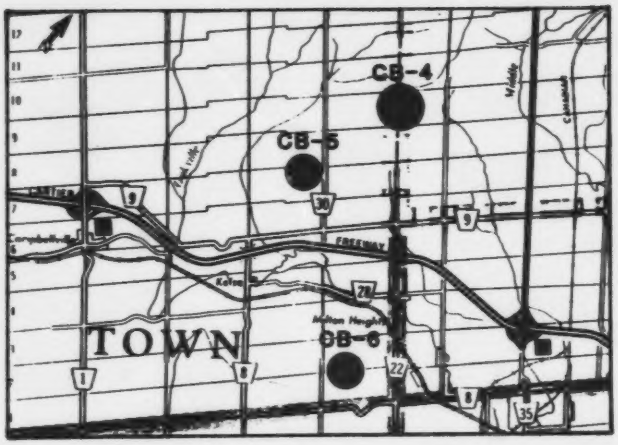


**Figure CB–5–1. LOCATION MAP FOR HALTON QUARRY.**

## CHEMICAL ANALYSES – 3/4 IN. STONE*

| | Components in Percent | |
|---|---|---|
| | 1 | 2 |
| **$SiO_2$** | 0.59 | 0.16 |
| **$Al_2O_3$** | 0.04 | 0.69 |
| **$Fe_2O_3$** | 0.46 | 0.33 |
| **CaO** | 31.08 | 30.28 |
| **MgO** | 20.59 | 21.02 |
| **S** | 0.04 | – |
| **$CO_2$** | 46.88 | 47.22 |
| **Total** | 99.68 | 99.70 |

** after Hewitt and Vos, 1972, p.52.*

### Geological Section

*Thickness*

*UNIT 4 Amabel Formation* *9.3m*

Dolostone: tan–brown, weathers dark brown; fine to very coarse crystalline; massive bedded, irregular and lensoid, contacts are gradational and irregular; calcite crystals in vugs; abundant crinoids, brachiopods and bryozoans; lenses pinch and swell with some zones being very fossiliferous; lower contact is gradational.

*UNIT 3 Amabel Formation* *9.17m*

Dolostone: dark grey to brown, weathers same; very fine to fine crystalline; thin to massive bedded, gradational contacts; abundant crinoids, bryozoans, rare brachiopods; grey banding is abundant in the lower half and may be failed stylolites; lower contact is gradational.

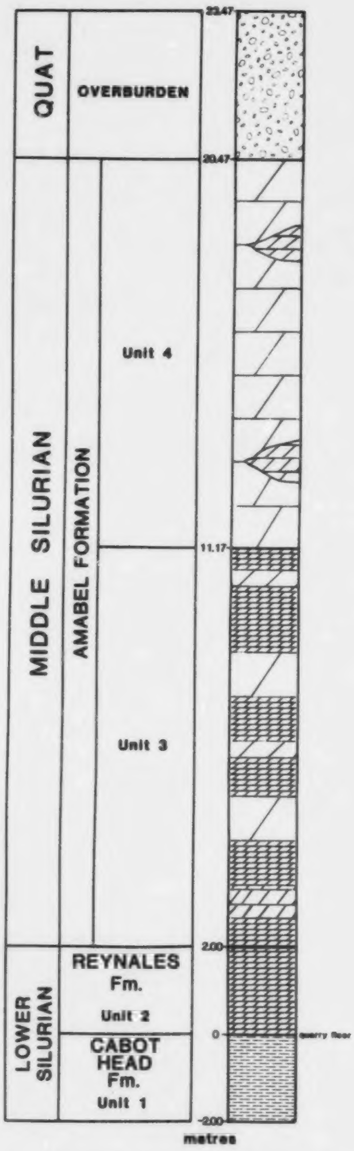


**Figure CB-5-2. STRATIGRAPHIC COLUMN FOR HALTON QUARRY.**

*UNIT 2 Reynales Formation* *2.0m*

**Dolostone: grey-green, weathers same; very fine crystalline; thin bedded (about 3 cm); pyrite mineralization on bedding planes and as irregular nodules; scattered fossil trails on bedding planes; lower contact is not exposed.**

*UNIT 1 Cabot Head Formation* *1.0m*

**Shale: olive green, weathers same; very fine- grained, clayey; no bedding; apparent dolomitic laminae are present; water covered.**

*Total thickness* *21.47m*

## QUARRY OPERATION

The bedrock surface is irregular and most overburden removal requires the use of a backhoe. The overburden material is used to rehabilitate the northwestern limit of the quarry. The quarry is presently excavated over an area of approximately 30 ha and mined on a single lift of 12 m to 22 m averaging 16 m in height. Blast holes are drilled at 175 mm diameter with a CP 650 rotary drill on a 4.6 m x 4.9 m pattern to 2.7 m subgrade. Borehole liners are placed in the hole and toe loaded with aluminized AN/FO, while straight AN/FO is used for the column charge, up to a 3.65 m collar. When encountering a wet hole, a water gel cartridge (NORGEL) is loaded at the toe and borehole liners are placed in the hole and loaded with AN/FO. All holes are primed at the toe by an Austin bottom hole primer and by 1 lb. boosters (column charge) initiated by primacord detonating cord. Each hole is delayed by 25 ms connectors at surface and by 35 ms safety delay connectors down the hole (one delay period per hole). Explosives are mixed and loaded at the site by a bulk explosive truck and a powder factor of approximately 0.32 kg/tonne is achieved. Blasting is carried out once a week and all shots are monitored by seismograph and sound monitor. Secondary breakage is performed by crane and 5-ton drop ball.

A single 6 in. electric Fraser Brace impeller suction pump is used to dewater the quarry and a Gorman-Rupp 10 in. diesel pump is available as a backup during spring and fall.

Blasted stone is loaded by Cat 988B (7 yd.) and Michigan 275C (7 yd.) loaders to 4 rear dump trucks. A combination of the following trucks are used for haulage: (1) R35 Euclid, (2) 74TD Euclid, (2) Terex 3307 (40 ton) and (1) Terex 3303 (22 ton).

## PROCESSING

The plant and quarry operate on a 12-month basis. Both portable and stationary crushing systems operate at the site.

Primary crushing is by Cedarapids 43 in. x 50 in. double impeller crusher (500 tph capacity), feeding a 4 ft. x 12 ft. triple deck Tyler screen. The Tyler screen produces -2 in. or 3/4 in. crusher run, 3 in. to 5 in. or 4 in. to 8 in. gabion stone to 115-tonne hoppers. A middle product of -4 in. + 2 in. or -4 in. + 3/4 in. is also produced and sent to a surge stockpile. Surge material is fed by a Jeffrey feeder to a triple-deck 7 ft. x 20 ft. Hewitt-Robins shaker screen with 2 in. top deck, 7/8 in. center deck, bottom deck consisting of two Dillon end tension sections with 1/4 in. opening and the remaining portion of the deck is covered with 1/4 in. cross slot wire cloth. The top and middle deck oversize is fed to a Hazemag APS 1320K crusher for reduction. A 2 in. clear product can be removed from this shaker prior to crusher by means of relocating a hand-operated gate and transferring the 2 in. clear to a short transfer conveyor followed by a 30 in. x 100 ft. stacker. HL8 and screenings are also produced on this shaker.

Material from Hazemag crusher is transferred to two Hewitt–Robins 7 ft. x 20 ft. triple–deck shaker screens with 7/8 in. square opening top decks and 1/2 in. square opening center decks. Each shaker has two sections of Dillon end tension cloth with a 1/4 in. opening followed by sections of 1/4 in. cross slot wire. Oversize products from these two shakers are transferred to a holding bin which is equipped with a variable speed drive for feeding product to a 4 1/4 ft. Symons standard crusher which has been set to 7/16 in. on closed side for final reduction. HL8 and HL3 1/4 in. screenings produced in this circuit are then transferred by ground conveyors to mobile radial stackers.

A portable crushing system of 171 tph capacity is operated at the surge stockpile. Stone from the surge pile (–4 in. + 3/4 in.) is loaded by a Michigan 275C to a feed hopper. The material is then crushed by an Eljay 54 in. cone crusher and passed over a 5 ft. x 20 ft. triple deck Eljay screen, producing 3/4 in. clear, HL3 or HL8, screenings and an oversize that is sent for recrushing.

All products are stockpiled and recovered by a Michigan 275C loader for shipping by truck. Two truck scales are operated at the plant, a 50 ft. scale with 80,000 lbs. capacity for inbound traffic and a 80 ft. scale with 100,000 lb. capacity for outbound trucks.

### PRODUCTS

Armour Stone
Gabion Stone
2 in. Crusher Run
3/4 in. Crusher Run
Granular "A"
2 in. Clear
3/4 in. Clear
Screenings (–5/16 in. + 200 mesh)
HL8 Concrete (–7/8 in. + 5/6 in.)
HL3 Concrete (–5/8 in. + 1/4 in.)

### MOBILE EQUIPMENT

#### Trucks

1 – R35 Euclid
2 – 74TD Euclid 27 ton
2 – Terex 3307 40 ton
1 – Terex 3303 22 ton

#### Loaders

1 – Cat 988B – 7 yd.
1 – Michigan 275C – 7 yd.
1 – Michigan 175C – 5 yd.
1 – Cat 966B – 4 yd.
1 – Cat 980C – 5 yd.

### REFERENCES

Hewitt, 1960, p. 120
Hewitt 1964a, p. 48–50
Hewitt and Vos, 1972, p. 52–53
ARIP 47, 1982, p. 20

### MAPS

Bond et al., 1976, ODM Map 2337

## CB–6 MILTON LIMESTONE — MILTON QUARRY

### LOCATION AND OWNERSHIP

The Milton Limestone Quarry is located 1.5 km west of Milton on the brow of the Niagara Escarpment, in Lots 1 and 2, Concession 7, Town of Milton (Nassagaweya Township), Regional Municipality of Halton (Figure CB–6–1). The quarry has been in operation since 1958 and is a division of LAC Minerals Ltd. The quarry licence covers an area of 93.72 ha.

### GEOLOGY

The quarry exposes 21.7 m of reefy, irregular massive–bedded dolostone of the Middle Silurian Amabel Formation (Figure CB–6–2).

The lowest 8 m of the Amabel Formation is stylolitic with abundant dark–grey laminations. The Reynales Formation underlies the Amabel with a thickness of 2.4 m. The top of the Reynales Formation is the quarry floor and, where exposed, has a gradational contact to the Amabel. Overburden ranges from nil to 9 m and averages about 2 m.

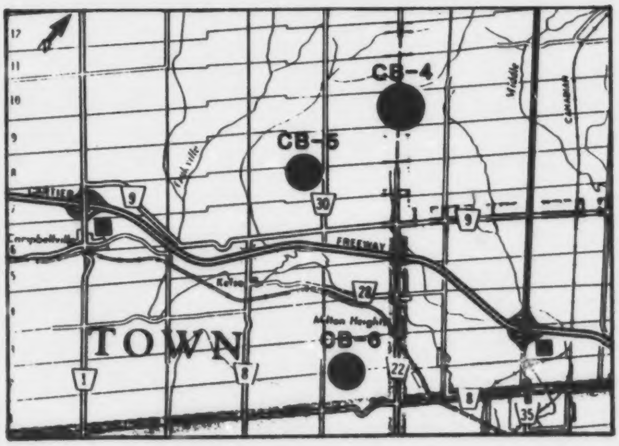


Figure CB–6–1. LOCATION MAP FOR MILTON QUARRY.

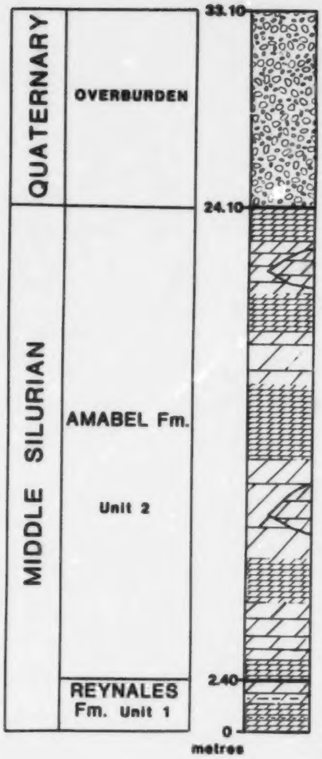


Figure CB-6-2. STRATIGRAPHIC COLUMN FOR MILTON QUARRY.

Photo CB-6-1. REEF CORE LENSES (TOP RIGHT) AND FLANKING ROCK OF THE AMABEL FORMATION; MILTON QUARRY.

## Geological Section

| | | Thickness |
|---|---|---|
| *UNIT 2* | *Amabel Formation* | *21.7m* |

Dolostone: light grey, weathers yellow-brown to grey; coarse crystalline; thin bedded to massive, contacts are sharp and slightly irregular; draping also occurs; crinoids and brachiopods are abundant with rare bryozoa; lower contact is the quarry floor.

| | | |
|---|---|---|
| *UNIT 1* | *Reynales Formations* | *2.4m* |

Dolostone: medium grey, weathers light to grey-brown; fine to medium crystalline; thin to medium bedded, contacts are sharp and slightly irregular with shale partings; pyrite and calcite in vugs; fossils include abundant crinoids and rare corals; becomes coarser crystalline up section. This unit acts as relief on quarry floor.

| | |
|---|---|
| *Total thickness* | *24.1m* |

## QUARRY OPERATION

The quarry operates all year and is currently advancing to the southwest on a single lift of about 25 m in height and approximately 300 m in length. The stripped overburden is used to rehabilitate the northeastern quarry limit. Blast hole drilling is performed by a contractor on a 4.3 m x 4.3 m pattern with 15 cm diameter holes. Blasting occurs approximately once a week and all blasts are monitored for vibration and noise levels. Holes are loaded with Magnafrac at the toe, aluminized AN/FO and/or straight AN/FO as the column charge, delivered and loaded by bulk truck. Four 1 lb. primers are used in each hole and blasting is initiated by non-electric caps. Secondary breakage is performed by crane and 3-ton drop ball. Water seepage is minimal, any quarry dewatering being handled by a 6 in. Flygt submersible pump.

## PROCESSING

The process flow sheet for the Milton Quarry of Milton Limestone is illustrated on Figure CB-6-3.

Blasted stone is loaded by a Cat 988B (7 yd.) loader into two Terex 3307 (40 ton) trucks which haul approximately 1,500 m to the primary crusher. The material is

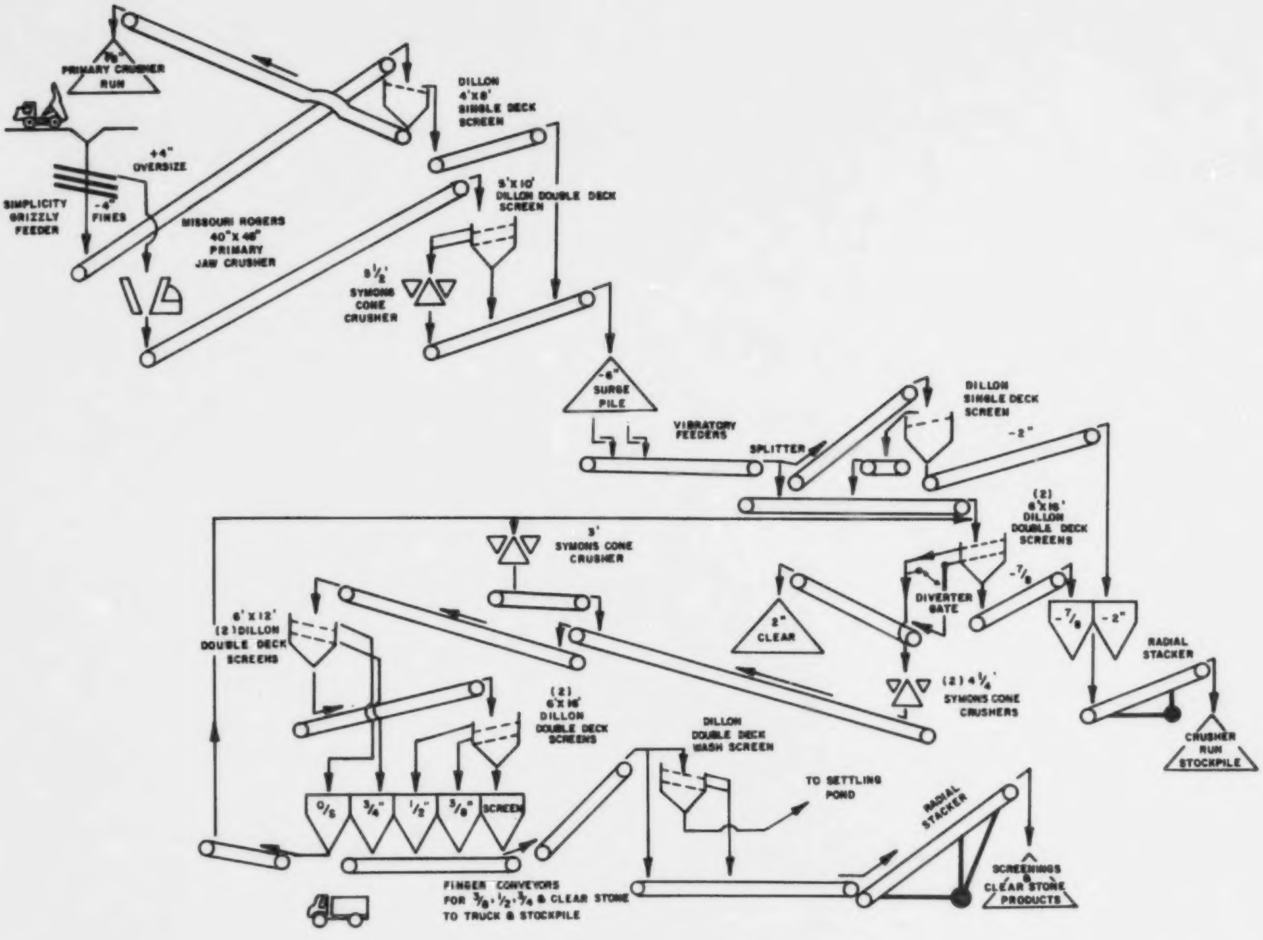

7/8" PRIMARY CRUSHER RUN
SIMPLICITY GRIZZLY FEEDER
+4" OVERSIZE
-4" FINES
MISSOURI ROGERS 40"X 48" PRIMARY JAW CRUSHER
DILLON 4'X 8' SINGLE DECK SCREEN
5'X 10' DILLON DOUBLE DECK SCREEN
5 1/2' SYMONS CONE CRUSHER
-6" SURGE PILE
VIBRATORY FEEDERS
SPLITTER
DILLON SINGLE DECK SCREEN
-2"
(2) 6'X 16' DILLON DOUBLE DECK SCREENS
3' SYMONS CONE CRUSHER
DIVERTER GATE
-7/8
2" CLEAR
-7/8
-2"
RADIAL STACKER
(2) 4 1/4' SYMONS CONE CRUSHERS
CRUSHER RUN STOCKPILE
6'X 12' (2) DILLON DOUBLE DECK SCREENS
(2) 6'X 16' DILLON DOUBLE DECK SCREENS
DILLON DOUBLE DECK WASH SCREEN
TO SETTLING POND
O/S
3/4"
1/2"
3/8"
SCREEN
RADIAL STACKER
SCREENINGS & CLEAR STONE PRODUCTS
FINGER CONVEYORS FOR 3/8, 1/2, 3/4 & CLEAR STONE TO TRUCK & STOCKPILE

Figure CB-6-3. PROCESS FLOW SHEET FOR MILTON QUARRY.

dumped into a feed hopper and sized by grizzly feeder; +4 in. is sent to a 40 in. x 48 in. Missouri Rogers primary jaw crusher and −4 in. undersize to a 4 ft. x 8 ft. single deck Dillon screen. Oversize (+7/8 in.) from the screen goes to a −6 in. surge pile and undersize to a 7/8 in. primary crusher run pile. Material leaving the primary crusher goes to a double deck 5 ft. x 10 ft. Dillon screen. The oversize is recrushed by a 5 1/2 ft. Symons cone crusher, added to the fines from the screen and sent to the −6 in. surge pile. Crushed stone is reclaimed from the surge pile by vibratory feeders and conveyed to a splitter chute. From the splitter chute, material can be screened and conveyed to a 2 in. crusher run storage bin (and distributed by a stacker to stockpile) or sent to two double deck Dillon 6 ft. x 16 ft. screens. Oversize from the Dillon screens is sent to two 4 1/2 ft. Symons cone crushers, the middle product to a 2 in. clear stockpile and fines to a 7/8 in. crusher run storage bin (and sent by a stacker to stockpile). Material leaving the two Symons 4 1/4 ft. cones is sized by two Dillon 6 ft. x 12 ft. double deck screens producing 1 1/2 in. and 3/4 in. clear to 100 tonne storage bins, and fines. The fines product is rescreened by two double–deck Dillon 6 ft. x 16 ft. screen producing 1/2 in. clear, 3/8 in. clear and −1/4 in. screenings that are sent to 100 tonne bins. Finger conveyors are available to transfer the 3/4 in., 1/2 in. and 3/8 in. clear stone to stockpile storage. The 1 1/2 in. and 3/4 in. clear stone can be sent from the bins for tertiary crushing by a 3 ft. Symons cone or as described earlier to two double deck Dillon 6 ft. x 16 ft. screens producing oversize to two 4 1/4 ft. Symons cone crushers and undersize to storage, etc. Material in clear

**Photo CB-6-2.**
**PROCESSING FACILITY (LOOKING SOUTHWEST); MILTON QUARRY.**

stone storage bins may also be conveyed to a Dillon wash screen and then to a stockpile. Two Michigan 275C loaders are utilized for the loading of customer's trucks. A 35-ton Caterpillar truck is used for handling and transporting of stockpile material.

### PRODUCTS

Gabion Stone
3 in. to 6 in.
8 in. to 14 in.
2 in. Crusher Run
7/8 in. Crusher Run
2 in. Clear
1 1/2 in. Clear
3/4 in. Clear
5/8 in. Clear
1/2 in. Clear
3/8 in. Clear
Screenings
HL8
HL3

### REFERENCES

Hewitt, 1960, p. 119
Hewitt, 1964a, p. 47
Vos, 1969, p. 40-42
Hewitt and Vos, 1972, p. 54-55
ARIP 47, 1982
Sabina, 1986, p. 138

### MAPS

Hewitt, 1969, ODM Map 2176
Bond et al., 1976, ODM Map 2337

## CB-7 NELSON AGGREGATE CO. — NELSON QUARRY

### LOCATION AND OWNERSHIP

The Nelson Quarry of Nelson Aggregate Co. is located on Guelph Line, 4 km north of Nelson Corners in Lots 1 and 2, Concessions 2 and 3, City of Burlington (Nelson Township), Regional Municipality of Halton as shown on Figure CB-7-1. This quarry, which is one of the largest in Ontario, began production in 1954 (Lots 1 and 2, Concession 3) and expanded in 1957 (Lots 1 and 2,

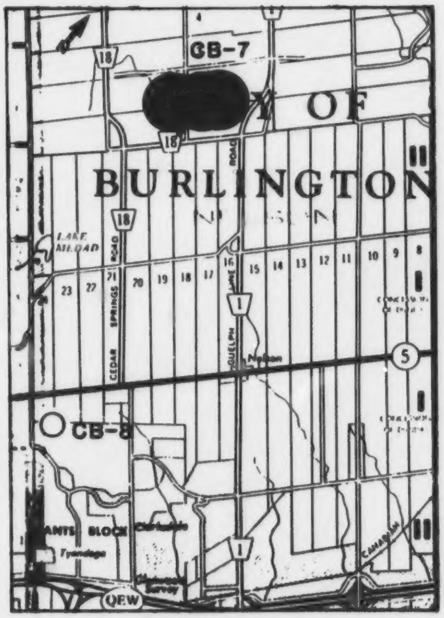


**Figure CB-7-1. LOCATION MAP FOR NELSON QUARRY.**

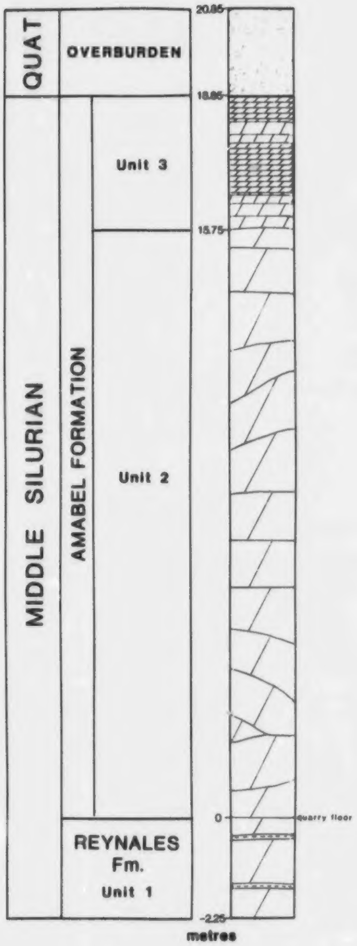

QUAT
OVERBURDEN
MIDDLE SILURIAN
AMABEL FORMATION
Unit 3
Unit 2
REYNALES Fm.
Unit 1
20.85
18.85
15.75
0
quarry floor
-2.25
metres

Figure CB-7-2. STRATIGRAPHIC COLUMN FOR NELSON QUARRY.

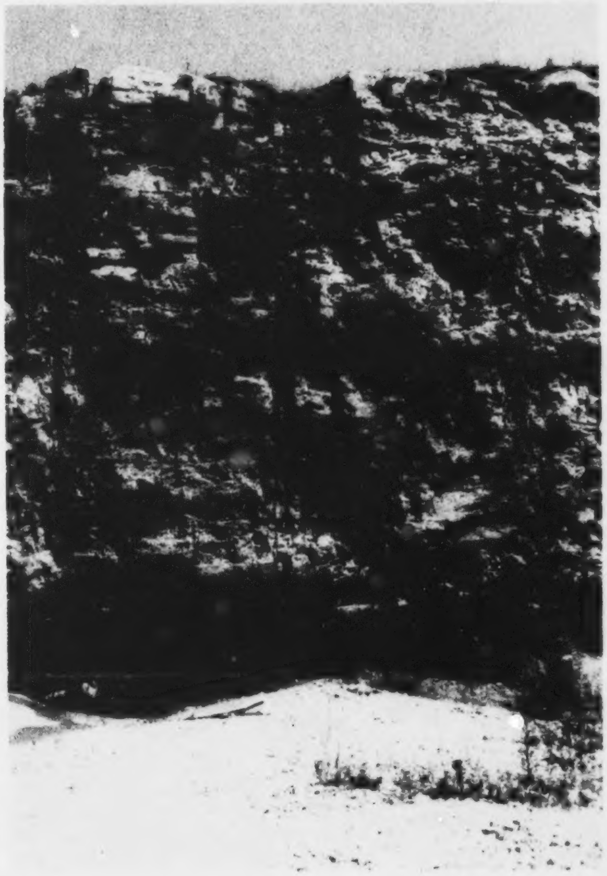


Photo CB-7-1. AMABEL AND REYNALES FORMATIONS AT THE NELSON QUARRY. THE SECTION IS ABOUT 18 m THICK.

Concession 2). The operation has a capacity in excess of 1.5 million tonnes per year in an average 10-month operating year. The quarry licence covers an area of 202.5 ha.

## GEOLOGY

This active quarry exposes 18.85 m of section from the Middle Silurian Amabel and Reynales Formations (Figure CB-7-2.) The lower part of the Amabel Formation is a fine- to medium-crystalline, reefal dolostone, massive with abundant stylolitic partings. The upper part is a coarse- to very coarse-crystalline, medium-bedded, reefal dolostone. Bioherms can be quite large (60 m in length and 10 m high) with dips of flank beds up to 20°. The Reynales Formation, interbedded argillaceous dolostone and shale, is exposed in the quarry sump.

Overburden, consisting of sand, clay and glacial till, ranges from 1 m to 7 m in thickness.

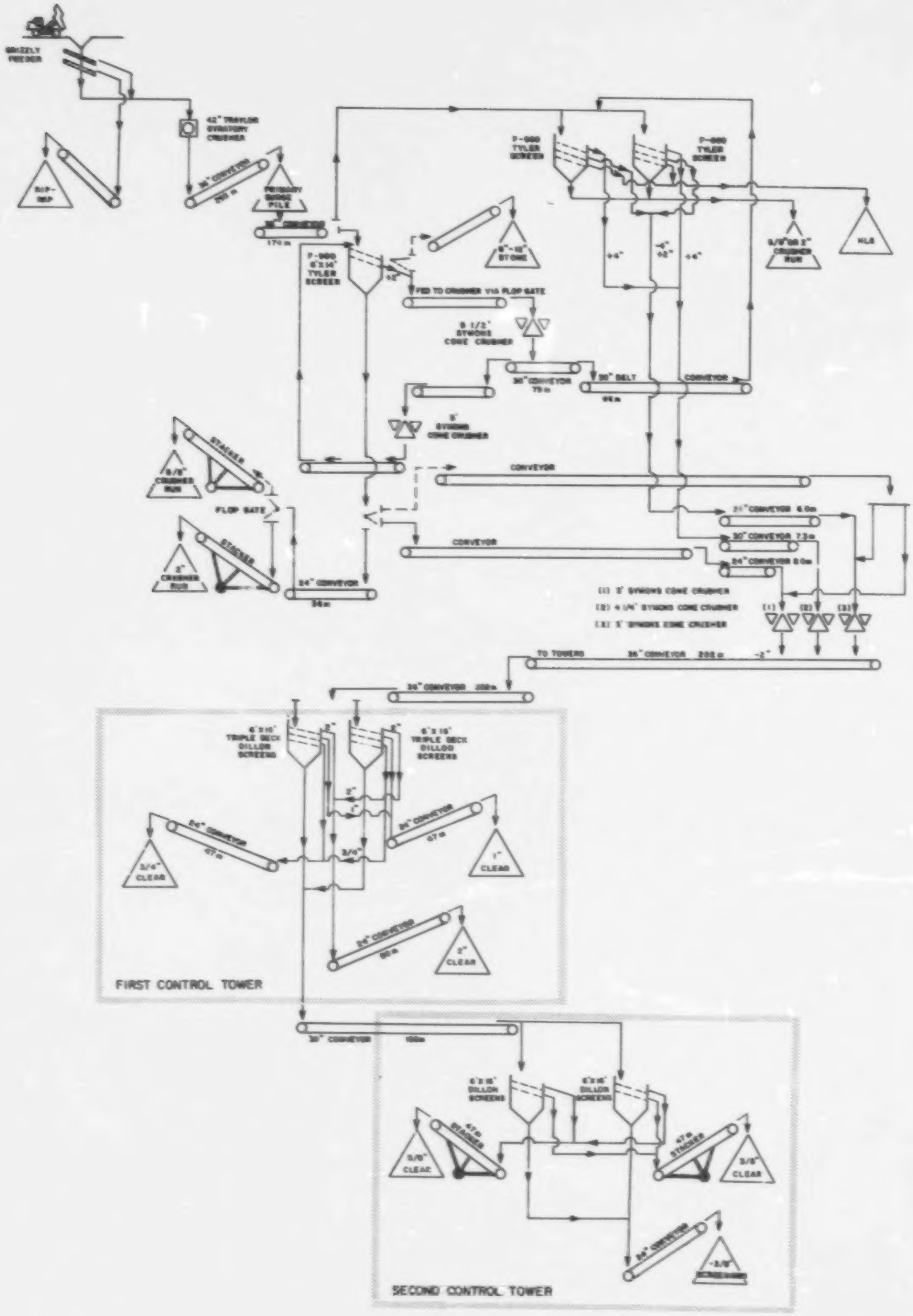

GRIZZLY FEEDER
42" TRAYLOR GYRATORY CRUSHER
RIP-RAP
36" CONVEYOR
260 m
PRIMARY SURGE PILE
36" CONVEYOR
170 m
F-900 6'X14' TYLER SCREEN
+2"
6"-12" STONE
FED TO CRUSHER VIA FLOP GATE
5 1/2' SYMONS CONE CRUSHER
30" CONVEYOR 75 m
30" BELT CONVEYOR
66 m
5' SYMONS CONE CRUSHER
F-900 TYLER SCREEN
F-900 TYLER SCREEN
+4"
-4" +2"
+4"
5/8" OR 2" CRUSHER RUN
HL8
STACKER
5/8" CRUSHER RUN
FLOP GATE
STACKER
2" CRUSHER RUN
24" CONVEYOR
36 m
CONVEYOR
CONVEYOR
21" CONVEYOR 6.0 m
30" CONVEYOR 7.3 m
24" CONVEYOR 8.0 m
(1) 3' SYMONS CONE CRUSHER
(2) 4 1/4' SYMONS CONE CRUSHER
(3) 5' SYMONS CONE CRUSHER
(1)
(2)
(3)
TO TOWERS
36" CONVEYOR 202 m
-2"
36" CONVEYOR 200 m
6'X16' TRIPLE DECK DILLON SCREENS
6'X16' TRIPLE DECK DILLON SCREENS
2"
2"
2"
1"
3/4"
24" CONVEYOR
47 m
3/4" CLEAR
24" CONVEYOR
47 m
1" CLEAR
24" CONVEYOR
60 m
2" CLEAR
FIRST CONTROL TOWER
30" CONVEYOR
100m
6'X16' DILLON SCREENS
6'X16' DILLON SCREENS
47 m STACKER
5/8" CLEAR
47 m STACKER
3/8" CLEAR
24" CONVEYOR
-3/8" SCREENINGS
SECOND CONTROL TOWER

**Figure CB-7-3. PROCESS FLOW SHEET FOR BURLINGTON PLANT OF NELSON AGGREGATE CO.**

### Geological Section

*Thickness*

*UNIT 3 Amabel Formation* *3.1m*

Dolostone: light grey, weathers buff-grey; coarse to very coarse crystalline; thin to medium bedded, contacts are sharp with leached stylolitic partings; abundant crinoidal debris; lower contact is undulatory and gradational.

*UNIT 2 Amabel Formation* *13.5m*

Dolostone: light to medium grey, weathers buff-grey; fine to medium crystalline; massive with sharp stylolitic partings; grey banding present; reef flanks drape 15 to 25°; vuggy horizon present 2-3 m above the base of the unit; crinoids are abundant, rare corals; lower contact is quarry floor.

*UNIT 1 Reynales Formation* *2.25m*

Dolostone with shaly partings: grey to dark grey, weathers buff; medium crystalline, massive bedding with irregular, sharp contacts and shaly partings; porous in places; pyrite in pores.

*Total thickness* *18.85m*

## QUARRY OPERATION

The bedrock surface is quite irregular and presents difficulties in stripping. Excavated overburden material is hauled to the old quarry boundaries and graded on a slope from the top of the quarry face to the quarry floor. Rapid growing vegetation is seeded along the slope to rehabilitate the site and prevent erosion.

A single 18 m bench is drilled on a 5.2 m x 5.2 m pattern at hole diameter of 165 mm by an Ingersoll–Rand DM25 rotary drill. Holes are toe–loaded with large diameter water gel cartridges and column–loaded with aluminized AN/FO. All blasting is initiated by non–electric blasting caps. Blasted stone is mucked by a Cat 988 loader or a P&H 1600 7 yd. electric shovel into 35– and 50–ton Euclid trucks and hauled approximately 1,500 m to stationary crushing facilities.

## PROCESSING

The process flow sheet for the Nelson Aggregates Burlington Plant is illustrated on Figure CB–7–3.

The delivered quarry run material is dumped into a feed hopper and sized by a grizzly feeder. The 9 in.–18 in. riprap stone is separated and conveyed to a stockpile with the balance being sent to a Traylor 42 in. primary gyratory crusher where the material is crushed to –12 in. The crushed stone is conveyed to a primary surge pile to provide feed for the various processing circuits. The crushed stone is reclaimed from the surge pile and passed over either a single Tyler F–900 screen or two Tyler F–600 screens.

The single Tyler F–900 screen produces either feed for the secondary crushing circuit or 6 in. – 12 in. gabion stone, in addition to 2 in. crusher run and 5/8 in. crusher run material which is delivered to the stockpile area by a series of conveyors and stackers. The secondary crushing circuit utilizes a 5 1/2 ft. Symons cone crusher to provide feed material for either of the two Tyler F–600 screens or the tertiary crushing circuit which comprises a 3 ft. Symons cone crusher in series with the Tyler F–900 screen.

The two Tyler F–600 screens produce a variety of products including 5/8 in. or 2 in. crusher run material, HL6 stone and crusher feed for parallel secondary crushing circuits utilizing two 3 ft. Symons cone crushers and one 4 1/4 ft. Symons cone crusher to produce feed for two control towers.

Feed to the first control tower is passed over two parallel triple deck Dillon screens which produce 2 in., 1 in., 3/4 in. clear stones as required. The undersize, –3/4 in. material, is conveyed to the second control tower and is passed over two parallel double deck Dillon screens which produce 5/8 in. and 3/8 in. clear stone as well as –3/8 in. screenings as required.

## PRODUCTS

Armour Stone
Riprap
Gabion Stone 6 in. to 12 in.
2 in. Crusher Run
3/4 in. Crusher Run
2 in. Clear
1 in. Clear
3/4 in. Clear
5/8 in. Clear
Screenings
HL6 Asphalt Stone

## REFERENCES

Hewitt, 1960, p. 113–118
Hewitt, 1964a, p. 45–46
Hewitt, 1968, pp. 11, 13, 20
Vos, 1969, p. 35–36
Hewitt and Vos, 1972, p. 55
ARIP 45, 1982, p. 18
Sabina, 1986, p. 138

## MAPS

Liberty, Bond and Telford, 1976, ODM Map 2336

# CB–8 OLD NELSON QUARRY

## LOCATION AND OWNERSHIP

The Old Nelson Quarry (previously called the Old Kerns Road Quarry and the Old Nelson Crushed Stone Quarry) is situated on the brow of the Niagara Escarpment overlooking the City of Burlington. It is 3 km northeast of Waterdown in Lot 24, Concession 1 S.D.S., City of Burlington (Nelson Township), Regional Municipality of Halton as shown on Figure CB–8–1.

## GEOLOGY

This quarry is of considerable geological significance as it is the most southerly exposure of the reefal, irregular–

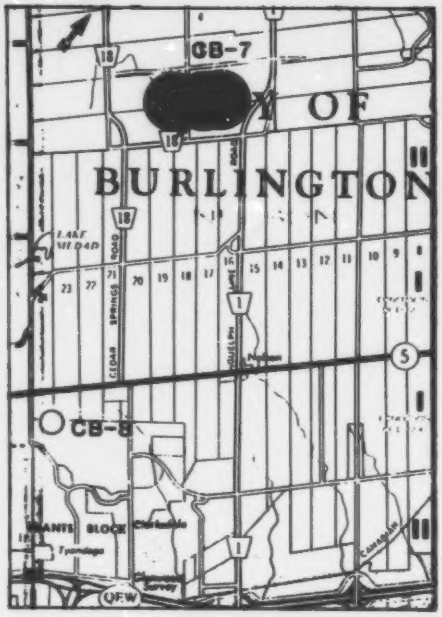


Figure CB-8-1. LOCATION MAP FOR OLD NELSON QUARRY.

bedded to massive Amabel Formation before the transition into the well-bedded Lockport Formation seen to the south in the Niagara Peninsula. The quarry exposes 15.65 m of section through the Middle Silurian Reynales, Irondequoit, Rochester and Amabel Formations (Figure CB-8-2). The units consist predominantly of shaly dolostones and dolostones. The quarry is now abandoned and is the subject of rehabilitation studies for possible use as a park. One to three metres of overburden is present.

## Geological Section

| | *Thickness* |
|---|---|
| *UNIT 4 Amabel Formation* | *12.00m* |

Three distinct facies are present in this unit, but occur in no apparent order.

(Facies 1)
Dolostone: light-grey to buff-grey, weathers buff-tan; medium to coarse crystalline; massive with irregular partings; large biohermal lenses are present, approximately 2 m thick and up to 4 m wide.

(Facies 2)
Dolostone: light grey to pink, weathers tan to light grey; medium to coarse crystalline; thin to thick bedded, contacts are sharp and planar; occasional fossil fragments are present.

(Facies 1)
Dolostone: mottled cream to light grey, weathers light grey; medium to coarse crystalline; medium bedded, contacts are sharp; very porous appearance; crinoidal debris occurs as large tabular lenses.

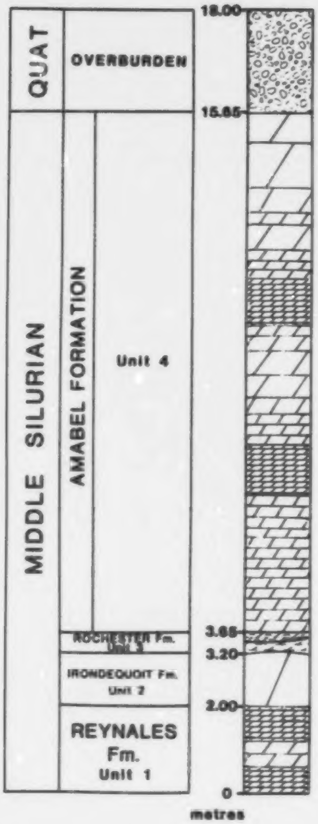


Figure CB-8-2. STRATIGRAPHIC COLUMN FOR OLD NELSON QUARRY.

| | |
|---|---|
| *UNIT 3 Rochester Formation* | *0.45m* |

Shaly dolostone and dolomitic shale: medium grey, weathers same; very fine crystalline with shaly zones; thin bedded, with shale partings, undulatory and irregular; rare brachiopods.

| | |
|---|---|
| *UNIT 2 Irondequoit Formation* | *1.20m* |

Dolostone: blue-grey, weathers grey to tan; fine to medium crystalline; massive bedded; vugs are abundant with calcite and gypsum (rare) mineralization; very porous; abundant fossils include crinoids and brachiopods, rare rugose and gastropods; lower contact is welded and disconformable with the Reynales Formation.

| | |
|---|---|
| *UNIT 1 Reynales Formation* | *2.00m* |

Dolostone, with shaly partings: buff-grey, weathers tan to light grey; fine crystalline; thin to medium bedded, contacts have shaly partings; scattered pyrite present in brachiopod molds and nodules; mud clasts with glauconite in lower 0.5 m and on quarry floor; pentamerids are very abundant, rare rugose corals.

| | |
|---|---|
| *Total thickness* | *15.65m* |

## REFERENCES

Hewitt, 1960, p. 113
Hewitt, 1968, p. 11

Vos, 1969, p. 35
ARIP 45, 1982, p. 18
Telford and Johnson, 1984, p. 10–11

### MAPS

Caley, 1941c, GSC Map 584A
Liberty, Bond and Telford, 1976, ODM Map 2336

## CB–9 FLAMBORO QUARRIES LTD.

### LOCATION AND OWNERSHIP

The Flamboro Quarry is located in Lot 6, Concession 4, Town of Flamborough (West Flamborough portion), Regional Municipality of Hamilton–Wentworth as shown on Figure CB–9–1. Crushed stone is transported by truck, supplying local road construction projects. The quarry licence covers an area of 41.30 ha.

### GEOLOGY

The Flamboro Quarry exposes 4.3 m of the Middle Silurian Lockport Formation (Eramosa Member) and 4.46 m of the Guelph Formation (Figure CB–9–2). The Eramosa Member is a brown, fine–crystalline dolostone which releases a strong petroliferous odor when freshly broken. The upper contact is gradational to the Guelph Formation, a grey–buff, fine– to medium–crystalline, vuggy dolostone. Bedding becomes slightly thicker in the Guelph Formation. Overburden is light, ranging from 0 to 30 cm in thickness.

### Geological Section

| | | Thickness |
|---|---|---|
| *UNIT 2* | *Guelph Formation* | *4.46m* |
| | Dolostone: grey to buff, weathers brown–buff; fine to medium crystalline; thin to medium bedded, irregular and undulatory contacts, some with stylolitic partings; sucrosic; porous zones; bituminous stylolitic partings; gradational lower contact. | |
| *UNIT 1* | *Lockport Formation, Eramosa Member* | *4.30m* |
| | Dolostone: dark to light brown, weathers medium brown; fine to medium crystalline; thin to medium bedded, with stylolitic partings, sharp contacts; calcite crystals in fossils and vugs; coral and brachiopod fossils present. | |
| *Total thickness* | | *8.76m* |

### QUARRY OPERATION

The quarry is worked on a single 7 m lift. Blast–hole drilling is contracted out with 16.5 cm diameter holes used in a 4 m x 5.5 m pattern. The holes are loaded with 1 lb. primers, primacord and AN/FO, and the thin–bedded strata allows good blasting fragmentation with no oversize stone produced. The broken rock is fed to a portable crushing system (jaw crusher, cone crusher and screens), approximately 100 m from the face, by Cat 988 loaders.

### REFERENCES

Goudge, 1938, p. 299

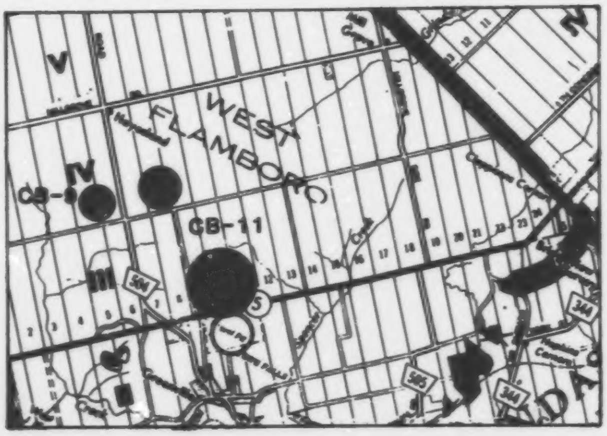


**Figure CB–9–1. LOCATION MAP FOR FLAMBORO QUARRY.**

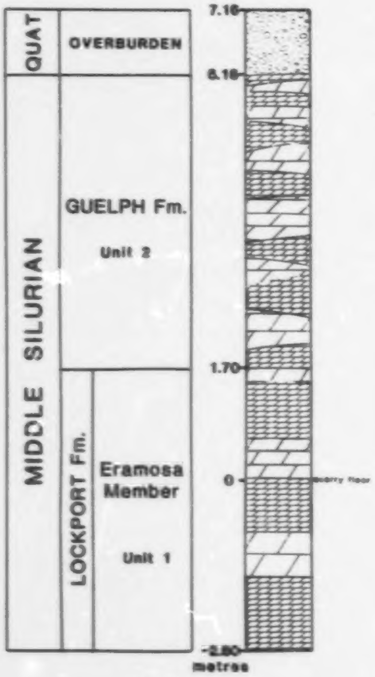


**Figure CB–9–2. STRATIGRAPHIC COLUMN FOR FLAMBORO QUARRY.**

Hewitt, 1960, p. 111
Hewitt, 1964a, p. 45
Hewitt and Vos, 1972, p. 50
ARIP 50, 1984, p. 37

### MAPS

Telford, 1979, OGS Map P.1983

## CB-10 CLAPPISON'S CORNERS QUARRY

### LOCATION AND OWNERSHIP

This abandoned quarry is located on the southeast corner of Clappison's Corners in Lot 12, Concession 3, Town of Flamborough (East Flamborough portion), Regional Municipality of Hamilton-Wentworth (Figure CB-10-1).

### GEOLOGY

The quarry exposes dolostones and shales of the Reynales, Irondequoit and Rochester Formations, capped by the Gasport and Goat Island Members of the Lockport Formation (Figure CB-10-2.) The Reynales Formation consists of grey-brown, fine- to medium-crystalline, interbedded dolostones and shales. The Irondequoit Formation is a crinoidal, dolomitic limestone, brown-buff in colour and fairly massive. The Rochester Formation is an argillaceous dolostone with interbedded shales. The Gasport Member of the Lockport Formation is a brown to buff, medium- to coarse-crystalline, thin-bedded and fossiliferous dolostone. This unit is capped by the Goat Island Member dolostones which are grey to buff, coarse crystalline and fossiliferous.

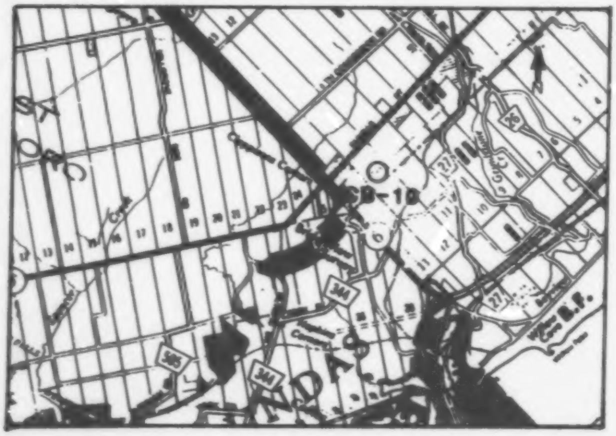


**Figure CB-10-1. LOCATION MAP FOR CLAPPISON'S CORNERS QUARRY.**

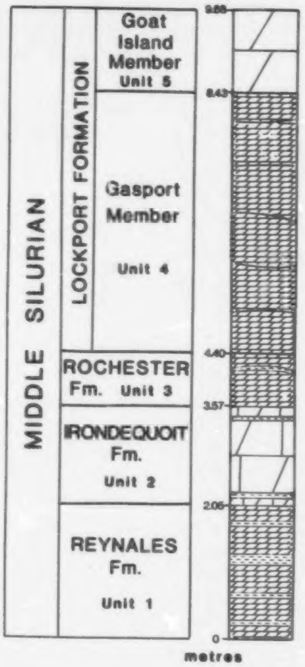


**Figure CB-10-2. STRATIGRAPHIC COLUMN FOR CLAPPISON'S CORNERS QUARRY.**

### Geological Section

| | | *Thickness* |
|---|---|---|
| *UNIT 5* | *Lockport Formation, Goat Island Member* | *1.25m* |

Dolostone: light grey, weathers buff; coarse crystalline; massive bedded, sharp contacts; marcasite in pores; zones of fossil debris (crinoid and brachiopod); stylolites present; sharp lower unit contact.

| | | |
|---|---|---|
| *UNIT 4* | *Lockport Formation, Gasport Member* | *4.03m* |

Dolostone: light grey-brown, weathers light buff; medium to coarse crystalline; thin bedded (3 to 8 cm), undulatory contacts; fossiliferous (crinoid and brachiopod); weathers blocky; sharp lower contact.

| | | |
|---|---|---|
| *UNIT 3* | *Rochester Formation* | *0.83m* |

Interbedded shales and dolostones: light grey dolostones and grey shales which weather dark grey; dolostones are fine crystalline, very thin bedded (2 to 3 cm), thickening towards the top (5 cm), contacts are undulatory and irregular; lamination present; 1 cm thick sulphide seam present 25 cm below the top; sharp lower contact.

| | | |
|---|---|---|
| *UNIT 2* | *Irondequoit Formation* | *1.52m* |

Dolomitic Limestone: light brown-grey, weathers brown-buff; medium to coarse crystalline; mainly massive with some thinner beds (0.05-1.0m), contacts are sharp with shaly partings; middle portion of the unit is barren of shaly beds; calcite pyrite, and marcasite occur in small pores and on shaly partings; crinoidal debris present; lower contact is sharp.

Amabel Formation
Rochester Formation
Irondequoit Formation
Reynales Formation
DODGE RAM

**Photo CB-10-1. MIDDLE SILURIAN FORMATIONS AT CLAPPISON'S CORNERS QUARRY.**

| | |
|---|---|
| *UNIT 1 Reynales Formation* | *2.05m* |

Interbedded dolostones and shales: medium grey dolostones, weathers brown-grey, buff-brown to grey shales; dolostones are fine to medium crystalline; thin-bedded with shaly contacts, beds are laterally extensive; fossil debris present on shaly partings.

| | |
|---|---|
| *Total thickness* | *9.68m* |

### REFERENCES

Goudge, 1938, p. 302–303
Hewitt, 1960, p. 112–113
Hewitt, 1964a, p. 45
Hewitt, 1968, pp. 11–12, 22
Vos, 1969, p. 35
Hewitt and Vos, 1972, p. 47
ARIP 50, 1984, pp. 21, 37
Sabina, 1986, p. 140–142

### MAPS

Liberty, Bond and Telford, 1976, ODM Map 2336

## CB-11 STEETLEY LIME & AGGREGATES DIVISION — DUNDAS QUARRY

### LOCATION AND OWNERSHIP

Steetley Lime & Aggregates Division of Steetley Industries Limited operates one of the largest stone quarries in Canada in terms of its size and product range. The Lime and Aggregates Division serves the construction, steel, glass, agricultural and filler markets with a wide range of products.

The Dundas Quarry of Steetley Lime & Aggregates is located northwest of the City of Hamilton and north of the Town of Dundas as shown on Figure CB-11- 1. The plant and quarry workings are situated in Lots 10 and 11, Concession 2, Lots 9 to 12, Concession 3, and Lots 7 to 10, Concession 4, Town of Flamborough (West Flamborough portion), Regional Municipality of Hamilton–

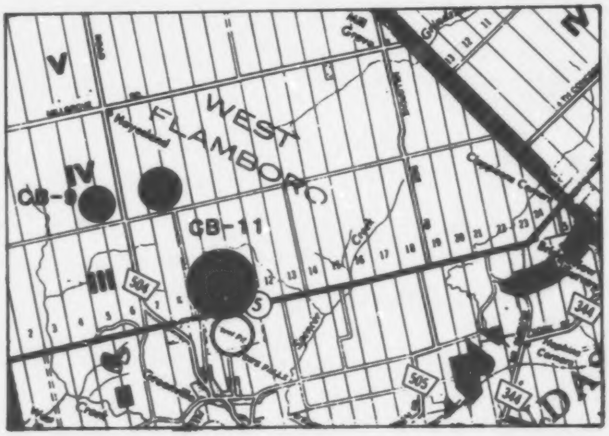


**Figure CB-11-1. LOCATION MAP FOR DUNDAS QUARRY.**

**Photo CB-11-1. AERIAL VIEW OF DUNDAS OPERATIONS OF STEETLEY LIME AND AGGREGATES. AGGREGATE OPERATION IS IN FOREGROUND, DOLOMITIC LIME PLANT IN BACKGROUND. EXTRACTION FROM QUARRY AT LEFT IS NOW COMPLETED.**

Wentworth. This area lies on both sides of Highway 5. Extraction has ceased in the quarry to the south of Highway 5, now the site of a modern aggregate plant, stone pulverizing plant, crushing plant and rotary kilns of Steetley Lime. Included on this site, but not operated by Steetley is a ready–mix concrete plant. Extraction is now taking place in the new quarry on Concession 4 north of the existing quarry. The total licenced area is 415 ha.

## GEOLOGY

The quarry north of Highway 5, in Lots 9 and 12, Concession 3, has two benches with a total rock thickness of 18 to 21 m, overlain by up to 15 m of silty till and lacustrine fine sands. The upper lift, of approximately 14 to 15 m in height, has produced stone used for aggregate, metallurgical stone, and dolomitic lime. The quarry face consists of 6 to 7 m of Guelph Formation rock which is a light grey, very fine–crystalline, medium–bedded dolostone, underlain by 6 to 8 m of the upper part of the Eramosa Member of the Lockport Formation. This rock is a medium light brown, very fine–crystalline, medium– to thick–bedded dolostone with some black shaly partings in the lower part of the section, and appears to be a transitional unit between the Guelph Formation and the Eramosa Member. This upper lift has been reported to have less than 0.5% silica and less than 0.5% alumina plus iron oxide, and is a high purity dolostone (Hewitt, 1960).

The 6 m lower lift is part of the Eramosa Member of the Lockport Formation. Characteristic of this member is the medium to dark brown or black, very fine–crystalline, thin–bedded dolostone. Laminations and petroliferous bands are common. Vugs occur in the lower part of the face and some may be filled with gypsum, calcite or chert. There is a higher concentration of silica and alumina in the Eramosa Member rock of this lift, evident in the visible increase in chert and shaly material.

### Geological Section

| | | *Thickness* |
|---|---|---|
| *UNIT 3* | *Guelph Formation* | *7.0m* |
| | Dolostone: brown–grey, weathers light grey; very fine crystalline; medium bedded. | |
| *UNIT 2* | *Lockport Formation, Eramosa Member* | *7.0m* |
| | Dolostone: medium brown, weathers light brown; very fine crystalline; medium to thick bedded; abundant shaly partings present in lower part; unit appears to be transitional between the Guelph and Eramosa. | |
| *UNIT 1* | *Lockport Formation, Eramosa Member* | *6.0m* |
| | Dolostone: medium brown, weathers dark brown to black; very fine crystalline; thin bedded, laminations and bituminous banding is common; vugs are present in the lower part and filled with gypsum, calcite or chert. | |
| *Total thickness* | | *20.0m* |

## QUARRY OPERATION

The following description is modified from Scott and Yundt, 1983. The dolostone quarried at Steetley is used for a variety of purposes, ranging from armour stone to dolomitic lime. Stone is quarried by drilling fourteen 60 cm holes on a 5.2 m x 6.1 m pattern with an Ingersoll–Rand DM45 drill and blasting with AN/FO and aluminized slurry. The blast rubble is loaded by a LeTourneau L800 (15 yd.) into three 75 tonne and four 55 tonne haulers and delivered to the processing plant.

## PROCESSING

The quarry run material is dumped into a 52 in. primary crusher in series with two 20 in. secondary gyratory crushers, capable of producing 1,000 tonnes per hour of –6 in. stone. Following primary reduction, the stone is crushed to 2 1/2 in. with two short head cone crushers and two 5 1/2 ft. standard cone crushers. Screening is by double–deck F800 Tyler screens as follows: two 6 ft. x 14 ft. screens with 2 1/2 in. and 1 1/2 in. openings; followed by two 7 ft. x 16 ft. screens with 7/8 in. and 3/4 in. openings; followed by two 6 1/2 ft. x 19 1/2 ft. screens with 1/2 in. and 5/8 in. openings; followed by two 6 ft. x 16 ft. screens with 1/4 in. and 1/8 in. openings. The secondary plant is designed to produce 1,000 tonnes per hour of a full range of stone sizes. The products are conveyed to surge piles or bins. Blending of sizes can occur to meet virtually any specification.

## AGGREGATE AND DRIED STONE PRODUCTS

The company offers more than 120 blends of products from various combinations of the 46 stockpiles. Numerous products exclusive of blended materials are produced, including the following from largest to smallest:

- armour stone, in 3 to 5 tonne, 5 to 6 tonne, and 6 to 9 tonne sizes, which is used for shore protection and has been shipped as far as Tobermory on Lake Huron.

- riprap material produced in the 4 in. to 12 in. size used in shore protection, and in the past 15 years over 3.6 million tonnes from this site have been used in the Hamilton Harbour area.

- metallurgical grade dolostone (2 in. x 1 in.) is used for blast furnace flux, as well as kiln feed to produce a range of dolomitic lime products for use in the steel and glass industries.

- concrete and asphalt aggregate is another major product, in sizes of –3/4 in. concrete aggregate, HL6 stone, HL5 wash stone, HL3 (–1/2 in.) stone, 1/4 in. chips for cold mix and surface treating, and manufactured sand.

Near the large aggregate plant is the dried fines pulverizing plant. Screenings from the aggregate plant are processed to produce materials destined for the agricultural, glass and filler markets.

- fertilizer grits, –1/8 in. + 1/16 in. and used as a fertilizer filler.

- a fine sand, –1/16 in. + 75 micron used in the glass industry and for cow bedding.

- agricultural limestone (agricultural index 75)

- fillers (–75 micron) for roofing shingles and sound deadeners.

In addition to the crushed and pulverized dolostone products there are several steel slag products produced at the nearby Old Brow Quarry site located a few kilometres away. The steel slag is processed as a skid–resistant aggregate replacing trap rock in many road surface applications. Three products are made: HL1; dense friction coarse (DFC) used in making asphalt pavement; and open friction coarse (OFC) which is used in asphaltic concrete to create a pavement that produces a lower decibel level and reduces hydroplaning.

## LIME – KILN OPERATIONS

The lime kilns are located at the eastern end of the processing plant area. There are three rotary kilns producing dolomitic lime and dead–burned dolomite at this site with the following specifications:

1. Kiln number 1 is a 350 ft. long F.L. Smidth kiln with a diameter of 9 ft. at the feed end and 10 ft. at the firing end. The clinker discharges to a Niems cooler. The kiln is fired by solid or oil fuels only.

2. Kiln number 2 is a 300 ft. long F.L. Smidth kiln of 10 ft. diameter for the full length, the clinker discharging to a Fuller grate cooler. It is fired by a solid or oil fuel, and can burn some gas.

3. Kiln number 3 is a 385 ft. long Fuller kiln of 11 1/2 ft. diameter for the full length, the clinker discharging to a Niems cooler. This kiln is fired by solid, oil or gas fuels.

The total production capacity from the three kilns is 350,000 tonnes per year requiring approximately twice as much feed. Two sizes of stone (–2 1/2 in. + 1 1/2 in., and –1 1/2 in. + 3/4 in.) are used as feed. Following burning, the clinker may be crushed and/or screened depending on the customer specifications. Product storage totals approximately 7,000 tonnes.

## KILN PRODUCTS

The larger feed material is used to make Dolime (soft burned dolomite) at a kiln temperature of 1,538°C. Dolime is used by the steel companies for slag conditioning in Basic Oxygen Furnaces and when in contact with molten steel the Dolime goes into solution, tying up the silica, which would destroy the furnace lining, and the sulphur which, if not removed, would result in a low quality steel.

The smaller size feed material is used to manufacture dead burned dolomite, called Dolomax, at kiln temperatures of 1,649°C to 1,760°C. Dolomax is coated with iron oxide (mill scale) and is used to fettle Open Hearths and Electric Furnaces.

Dolopel is a double burned, special hard, high–purity dolomite grain for the production of resin bonded and fired refractory bricks. Another special product, Dolomax "G", is used as a refractory raw material in gun mixes to protect the linings of steelmaking vessels.

A new product called Ferrodolime is a soft burned dolime, coated with iron oxide in the kiln, and is used as a slag conditioner in the Basic Oxygen Furnaces and Electric Furnaces. The iron oxide coating creates a dust-free product that goes into solution more readily.

### REFERENCES

Goudge, 1938, p. 300–302
Caley, 1940, p. 63
Hewitt, 1960, p. 106–110
Hewitt, 1964a, p. 44
Hewitt, 1968, pp. 12–13, 14, 22
Hewitt and Vos, 1972, p. 47–148
Segall and Dunn, 1972, p. 21
Winder and Sanford, 1972, p. 61–62
Scott and Yundt, 1983, p. 27–28
ARIP 50, 1984, pp. 19–20, 37
Sado et al., 1985, p. 24–27
Sabina, 1986, p. 143

### MAPS

Caley, 1941c, GSC Map 584A
Liberty, Bond and Telford, 1976, ODM Map 2336

## CB–12 TARO AGGREGATES INC. — STONEY CREEK QUARRIES

### LOCATION AND OWNERSHIP

Taro Aggregates Inc. owns a property in Lots 25–28, Concession 6, City of Stoney Creek (Saltfleet Township), Regional Municipality of Hamilton–Wentworth (Figure CB–12–1). The property is located at the top of the Niagara Escarpment, on the southern edge of Stoney Creek, west of Highway 20 and contains two operations known as the east and west quarries. The west quarry, in Lots 27 and 28, has been in operation since the turn of the century, and only ceased operations in December, 1986. The quarry was owned and operated by A. Cope and Sons Ltd., a family–owned construction company, until 1971 when Taro Aggregates Inc. and partners purchased the company. In 1978, Taro acquired a 100% interest and divested itself of the construction division.

After the completion of mining operations at the west quarry at the end of 1986 a 25–hectare parcel (section of west quarry) was donated to the City of Stoney Creek. Operations continue on a new licence on the south half of Lots 25 and 26 for the east quarry. The property comprises several parcels which total 166 ha.

### GEOLOGY

The two quarries display approximately 19 m of the Eramosa Member and the Vinemount shale beds of the Lockport Formation (Figure CB–12–2). The Vinemount shale beds are a grey, shaly dolostone, fine crystalline and medium–bedded. Chert and gypsum nodules are present and the unit has a distinct petroliferous odor. It is overlain by a grey–brown, fine– to medium–crystalline, thin–bedded dolostone of the Eramosa Member. Some shaly partings are present which also release a petroliferous odor when freshly broken.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 2 Lockport Formation, Eramosa Member* | *13.10m* |
| Dolostone: brown–grey, weathers grey; fine to medium crystalline; thin to medium bedded, sharp contacts with bituminous and shaly partings; calcite and gypsum nodules present; crinoids and brachiopods common in shaly partings; vuggy; porous; has a petroliferous odor; slump features present; blocky fracture pattern; transitional lower contact. | |
| *UNIT 1 Lockport Formation, Vinemount shale beds* | *6.28m* |
| Shaly dolostone: light grey, weathers dark grey; fine crystalline; medium bedded, sharp contacts with fine, undulatory laminae; shale/dolostone ratio 75/25; gypsum and calcite nodules present, sphalerite occurs along shaly partings; trace fossils present with silt infill; petroliferous odor when freshly broken; subconchoidal fracture; shale beds possess parallel lamination. | |
| *Total thickness* | *19.38m* |

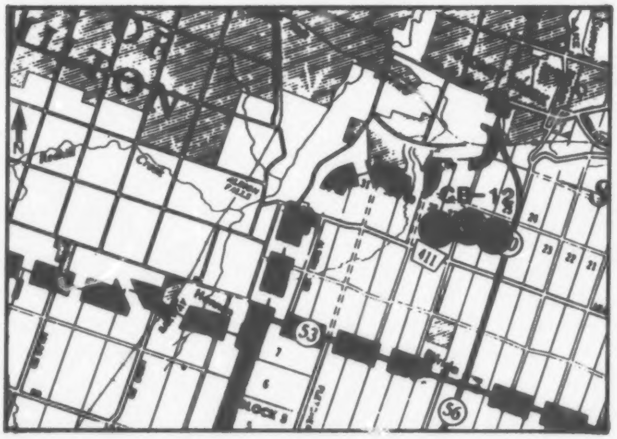


**Figure CB–12–1. LOCATION MAP FOR STONEY CREEK QUARRIES.**

## CHEMICAL ANALYSES – LOCKPORT FORMATION, ERAMOSA MEMBER*

| | Components in Percent | | | | | | |
|---|---|---|---|---|---|---|---|
| Sample No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Depth from surface metres | 0.0–1.5 | 1.5–3.1 | 3.1–4.6 | 4.6–6.1 | 6.1–7.6 | 7.6–9.1 | 9.1–10.7 |
| $SiO_2$ | 1.97 | 1.07 | 1.26 | 1.06 | 1.64 | 1.86 | 4.12 |
| $Al_2O_3$ | 2.02 | 0.91 | 1.34 | 0.86 | 0.50 | 1.19 | 1.87 |
| $Fe_2O_3$ | 0.58 | 0.38 | 0.48 | 0.45 | 0.48 | 0.53 | 0.82 |
| MgO | 20.7 | 20.7 | 21.7 | 21.5 | 21.3 | 21.3 | 20.7 |
| CaO | 28.7 | 28.7 | 27.9 | 27.6 | 27.9 | 27.9 | 26.6 |
| $CO_2$ | 44.4 | 45.6 | 44.8 | 45.7 | 44.4 | 43.0 | 43.4 |
| S | 0.03 | 0.03 | 0.12 | 0.05 | 0.14 | 0.26 | 0.37 |
| Total | 98.4 | 97.4 | 97.6 | 97.2 | 96.4 | 96.0 | 97.9 |

**After Hewitt and Vos, 1972, p. 49.*

Photo CB-12-1. VINEMOUNT SHALE AND ERAMOSA MEMBER AT STONEY CREEK QUARRIES.

Lockport Formation
Eramosa Member
Lockport Formation
Vinemount shale

Photo CB-12-2. STONEY CREEK (WEST) QUARRY (LOOKING SOUTHWEST).

## QUARRY OPERATION

The quarry operations in place at the time of the field work in 1986 are described in this report. Blasting design techniques focus on minimizing blast vibration and a large 9 m berm separates the quarry from local housing. A single 8.5 m lift is drilled on a 2.4 m x 2.7 m pattern with 7.6 cm diameter holes by two Ingersoll–Rand VL–671 air track drills (equipped with dust suppression systems) and a 1400 cfm compressor. All blast holes are stemmed by 1.2 m with stone chips and initiated with Nonel delay caps at the bottom of the holes, kicking out the bottom of the shot and allowing the upper section to break downward and horizontally away from the face. Each hole has a 42 ms delay, resulting in 40 lbs. of explosive delayed per hole. The quarry floor is very smooth due to the blasting allowance of a thin buffer of dolostone above the underlying shale. A maximum 15 cm subgrade is drilled.

Blasted stone is loaded by two Cat 988B 7 1/2 yd. A Poclain marble rock breaker is used for secondary breakage.

## PROCESSING

The process flow sheet for Stoney Creek Quarries is shown on Figure CB–12–3.

The crushing and screening plant is located in the east quarry. A 43 in. x 53 in. Cedarapids twin impeller crusher breaks the stone to −6 in. and this is carried approximately 250 m by a 36 in. conveyor to a surge bin. Stone from the surge bin is fed to a Cedarapids 5 ft. x 16 ft. triple deck screen that produces Granular "A", 2 in. clear and −6 in. + 2 in. oversize that is recrushed in an Eljay 54 in. cone. The Eljay crusher feeds a 5 ft. x 16 ft. triple–deck Cedarapids horizontal screen. The −9/16 in. fines are sent to a 6 ft. x 16 ft. Dillon triple–deck screen and separated into −9/16 in. + 3/8 in. (1/2 in. chips), −3/8 in. + 1/4 in. (HL3 asphalt stone) and screenings. If desired, a 4 ft. roller crusher and Assinck 4 ft. x 12 ft. portable screen are available to recrush the 1/2 in. chips.

Dust sources in the plant are as strictly controlled as in the drilling operations. Water is applied to all belts, though not so much as to create a build–up that would clog the screens. Taro Aggregates supplies primarily 3/4 in. stone for residential construction (weeping tile, basement foundation, driveways, etc.) within a 12 km radius of the plant.

## REFERENCES

Hewitt, 1960, p. 103–105
Hewitt, 1964a, p. 44
Vos, 1969, p. 32–33
Hewitt and Vos, 1972, p. 49–50
ARIP 50, 1984, p. 37
Sabina, 1986, p. 143–144

## MAPS

Caley, 1941c, GSC Map 584A
Liberty, Feenstra and Telford, 1976a, ODM Map 2343

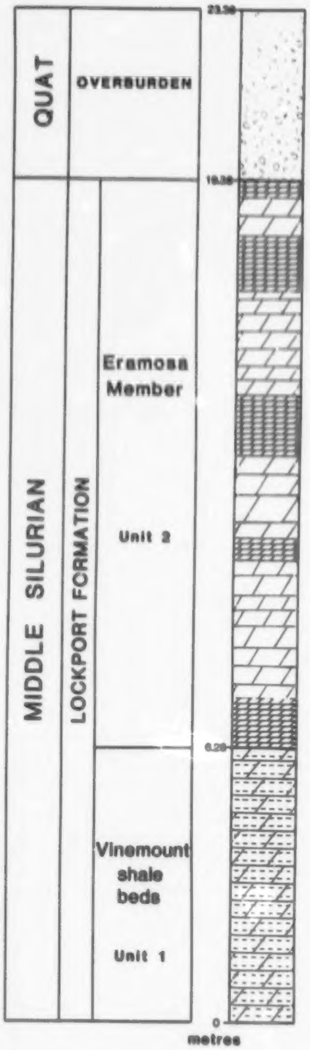


Figure CB-12-2. STRATIGRAPHIC COLUMN FOR STONEY CREEK QUARRIES.

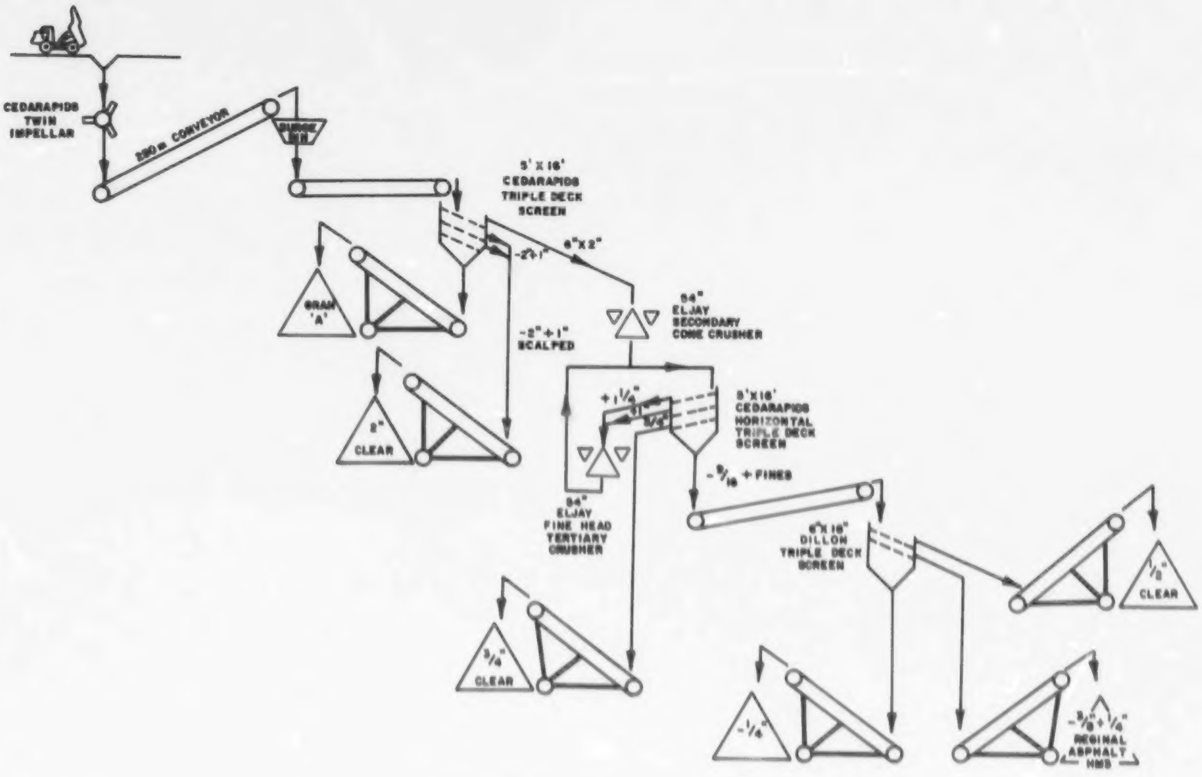

CEDARAPIDS TWIN IMPELLAR
290 m CONVEYOR
SURGE BIN
5' X 16' CEDARAPIDS TRIPLE DECK SCREEN
6"X 2"
-2"+1"
GRAN 'A'
-2" + 1" SCALPED
54" ELJAY SECONDARY CONE CRUSHER
2" CLEAR
+1 1/4"
3/4"
5'X16' CEDARAPIDS HORIZONTAL TRIPLE DECK SCREEN
- 5/16 + FINES
54" ELJAY FINE HEAD TERTIARY CRUSHER
6'X16' DILLON TRIPLE DECK SCREEN
1/2" CLEAR
3/4" CLEAR
-1/4"
-3/8" + 1/4"
REGINAL ASPHALT HMS

Figure CB-12-3. PROCESS FLOW SHEET FOR STONEY CREEK QUARRIES.

## CB-13 WATERFORD SAND AND GRAVEL LTD. — VINEMOUNT QUARRY

### LOCATION AND OWNERSHIP

This quarry is located 4 km south of Winona in Lot 5, Concession 5, City of Stoney Creek (Saltfleet Township), Regional Municipality of Hamilton–Wentworth (Figure CB–13–1). At the time of the field visit in 1986, the quarry was being dewatered. Quarrying operations and production of crushed stone were planned for 1987. The licenced area of the quarry is 20 ha.

### GEOLOGY

The quarry exposes a total of 19.47 m of the Goat Island Member, Vinemount shale beds and Eramosa Member of the Lockport Formation (Figure CB–13–2). The lower part of the Goat Island Member is a brown–grey, medium–crystalline, fine–to medium–bedded dolostone with stylolitic and bituminous partings. This unit contains 2.4 m of the informally named Ancaster Chert Beds. Calcite and gypsum mineralization is prevalent throughout.

The Goat Island Member is overlain by a black–grey shaly dolostone informally termed the Vinemount shale beds. Trace fossils are very common in the Vinemount shale beds, along with abundant brachiopods and crinoidal debris and gypsum and calcite nodules. The Vinemount shales are in turn overlain by the Eramosa Member (4.16 m) which consists of light to medium brown, fine– to medium–crystalline, thin–bedded dolostone. Shaly partings persist in the upper 2 m with zones of abundant crinoidal debris.

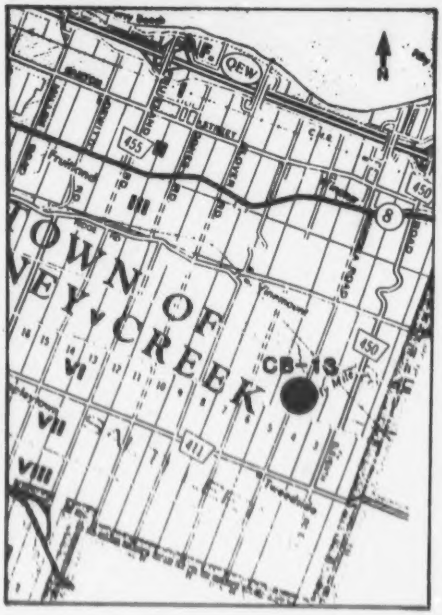

QEW
1
455
8
450
OWN OF
EY CREEK
CB-13
VI
VII
VIII
411
N

Figure CB-13-1. LOCATION MAP FOR VINEMOUNT QUARRY.

### Geological Section

*Thickness*

*UNIT 5 Lockport Formation, Eramosa Member* *4.16m*

Dolostone: dark to light brown, weathers buff-grey; fine to medium crystalline; thin bedded, sharp - irregular contacts with shaly partings in the lower 2 m; rich crinoidal zones; vuggy; laminations present; lower contact is sharp.

*UNIT 4 Lockport Formation, Vinemount shale beds* *4.82m*

Interbedded argillaceous dolostones and shales: light buff to dark brown, weathers buff; fine to medium crystalline; thin bedded, laminated with sharp contacts; very shaly in places; sedimentary features present include flame structures and graded beds; gypsum and calcite nodules throughout; fossils present include brachiopods, crinoids and trace fossils; sharp lower contact.

*UNIT 3 Lockport Formation, Goat Island Member* *2.02m*

Argillaceous dolostone: light grey to dark brown, weathers grey-black; fine crystalline; medium bedded, sharp irregular contacts; interbedded shaly zones with abundant trace fossils; sucrosic; buff coloured chert beds and nodules present in upper 1 m (very irregular); gypsum and calcite scattered throughout; lower contact is sharp.

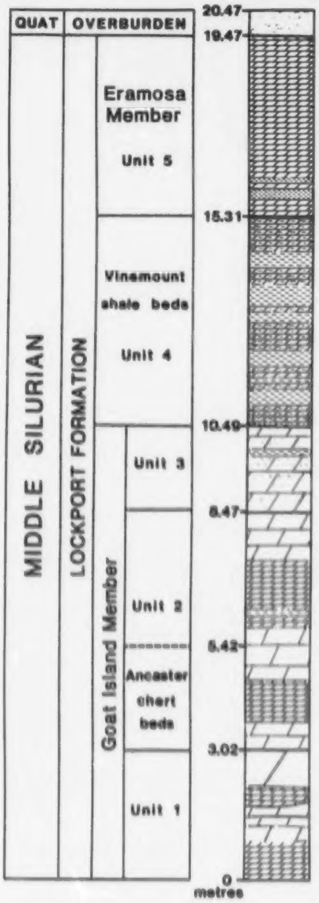

QUAT
OVERBURDEN
MIDDLE SILURIAN
LOCKPORT FORMATION
Eramosa Member
Unit 5
Vinemount shale beds
Unit 4
Goat Island Member
Unit 3
Unit 2
Ancaster chert beds
Unit 1
20.47
19.47
15.31
10.49
8.47
5.42
3.02
0
metres

Figure CB-13-2. STRATIGRAPHIC COLUMN FOR VINEMOUNT QUARRY.

*UNIT 2 Lockport Formation, Goat Island Member* *5.45m*

Dolostone: medium to grey-brown, weathers grey-brown; very fine to medium crystalline; thin to medium bedded (3 to 40 cm), contacts are shaly or stylolitic; has a bituminous odor; some shaly partings present; lower 2.4 m of unit has extensive chert lenses (2 to 3 cm thick) and is referred to as the Ancaster Chert Beds; gypsum and calcite nodules occur in vugs; lower contact is sharp.

*UNIT 1 Lockport Formation, Goat Island Member* *3.02m*

Dolostone: medium grey, weathers light buff; medium crystalline; thin to medium bedded, contacts are irregular, shaly and sometimes bituminous; upper beds are massive with undulatory and irregular contacts; banding is common; large white gypsum nodules (2x15cm) occur in vugs; calcite mineralization is also present in vugs, some surround gypsum crystals.

*Total thickness* *19.47m*

Lockport Formation
Eramosa Member
Lockport Formation
Vinemount shale beds
Lockport Formation
Goat Island Member

Photo CB-13-1. UNITS OF THE LOCKPORT FORMATION AT THE VINEMOUNT QUARRY.

## REFERENCES

Goudge, 1938, p. 307–308
Hewitt, 1960, p. 100–103
Hewitt, 1964a, p. 44
Vos, 1969, p. 21
Hewitt and Vos, 1972, p. 47
ARIP 50 1984, pp. 19. 37
Sabina, 1986, p. 144

## MAPS

Caley, 1941c, GSC Map 584A
Liberty, Feenstra and Telford, 1976a, ODM Map 2343

# CB–14 ARRISCRAFT CORPORATION

## LOCATION AND OWNERSHIP

Arriscraft Corporation has its plant and head office located on Speedsville Road, immediately north of Highway 401 in Cambridge, Ontario. The plant produces dressed stone with the trade name "Adair Marble" made from blocks of Amabel Formation dolostone which is quarried near Wiarton (site O–1 in Owen Sound District) and trucked to Cambridge. The company also manufactures an artificial calcium silicate building stone and brick. While markets for Adair Marble were strong in 1986, the natural stone division accounted for only about one–quarter of the company's revenues.

The company's production began in 1949 based on artificially coloured concrete stone. In 1956 the company's founder, E.G. Ratcliffe, developed a line of calcium silicate based building stone products. These have been marketed under such trade names as Citadel, Garrison, Ramparts Building Stone, Renaissance Masonry Units, Angelstone and Pioneer Brick.

## MANUFACTURED STONE

Manufactured stone products are made from natural sands, lime and colouring pigments. Glacial sand from the plant property is the major constituent, augmented by Nepean Formation sandstone from a quarry near Elgin in eastern Ontario when improved whiteness is desired. About 20% of quicklime is added to the sands and the mixture is held in two reactor bins at about 140°C. Various mineral pigments (mostly iron oxides) are introduced to the batch via two rod mills. A variety of product shapes are made in two Chisholm, Boyd and White presses and are cured for 8 hours in two autoclaves under a steam pressure atmosphere of 69 Mpa (10,000 p.s.i.). Special face texturing is applied by hand and through various splitting and finishing techniques. The result is a range of attractive manufactured sandstones in a variety of earth tone colours. Products include rock–face ashlar, random fieldstone, rectangular building stones and antique bricks for interior and exterior uses.

## NATURAL STONE

Natural stone is dressed in an adjoining plant. Mill blocks of thick–bedded Lockport Formation (Wiarton–Colpay Bay Member) dolostone are delivered by flat–bed truck from the Adair Marble Quarry (0–1) 200 km to the north (near Wiarton). They are off–loaded by forklift and placed in inventory for 2 or 3 months for seasoning. The process of eliminating "quarry sap" is not well understood, but it is believed to be related to moisture in rock pores which otherwise can cause spalling and other undesirable fracturing. Mill blocks are first trimmed by one of three large diameter (2 m) diamond–tipped circular saws. Sized blocks are then slabbed by a modified gang saw or multiple saw equipped with as many as 16 blades. Slabs of 1 1/4 in. and 2 1/4 in. are common thicknesses. Sawn faces may be textured by honing, sandblasting, bush hammering, flame finishing or conventional polishing. Final sizing is done with circular diamond saws. In 1986 the plant produced 15,000 pieces for the new Canadian embassy in Washington, D.C., involving 3,000 different sizes.

Quarrying of natural stone began in 1968 with the acquisition of the R.G. Ebel quarry (0–6) at Hope Bay. In 1979 the present Adair quarry (0–1) was opened in the same vicinity. Early production was mainly hearth slabs and sills, and it wasn't until 1980 that substantial production of building stone slabs was initiated. Products now include sills, coping, coursing stone, paving stone, slabbing and thin wall overlays. The company markets and distributes its products throughout North America by a dealer network of nearly 300.

Photo CB-14-1. TRIMMING MILLBLOCKS WITH A LARGE DIAMOND SAW AT THE CAMBRIDGE PLANT OF ARRISCRAFT CORPORATION.

# Niagara District

## INTRODUCTION

The Niagara District is situated in the Central Region of southern Ontario and includes all or portions of the Regional Municipalities of Niagara and Haldimand–Norfolk as shown in Figure NI–0–1.

Seventeen quarry properties are currently licensed in the Niagara District; 11 are active at the present time. The balance of the properties represent past producing quarries or those properties designated for future production. The quarries are located either along the Niagara Escarpment which trends east–west across the northern half of the district or along the discontinuous east–west trending Onondaga Escarpment which occupies the southern half of the district.

All of the quarries currently in production and those past producing quarries of geological significance were visited during the study and include the following:

| | |
|---|---|
| *NI–1* | *Nelson Aggregate Co. – Lincoln Quarry (active)* |
| *NI–2* | *Vineland Quarries and Crushed Stone – Vineland Quarry (active)* |
| *NI–3* | *Walker Brothers Quarries Ltd. – Thorold Quarry (active)* |
| *NI–4* | *Steetley Industries Ltd. – Queenston Quarry (active)* |
| *NI–5* | *Standard Aggregates Incorporated – Hagersville Quarry (active)* |
| *NI–6* | *Nelson Aggregate Co. – West Oneida Quarry (intermittent)* |
| *NI–7* | *Nelson Aggregate Co. – Oneida Quarry (intermittent)* |
| *NI–8* | *Cayuga Materials and Construction – Cayuga Quarry (active)* |
| *NI–9* | *Sweets Corners Quarries (abandoned)* |
| *NI–10* | *Dunnville Rock Products Ltd. Quarry (active)* |
| *NI–11* | *Hard Rock Paving Co. Ltd. – R. E. Law Quarry (active)* |
| *NI–12* | *Port Colborne Quarries Ltd. – Port Colborne Quarry (active)* |
| *NI–13* | *Bertie Bay Quarry (abandoned)* |
| *NI–14* | *Ridgemount Quarries Ltd. – Pit 1 (intermittent)* |

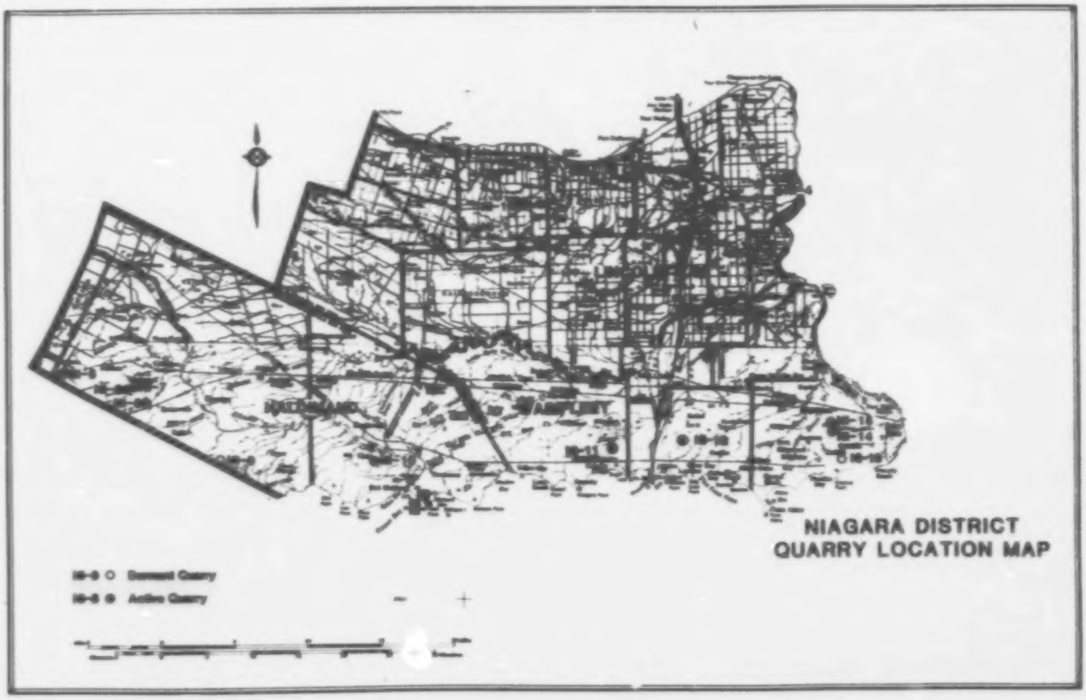


Figure NI–0–1. NIAGARA DISTRICT QUARRY LOCATION MAP.

*NI–15 Ridgemount Quarries Ltd. – Pits 2 and 3 (active)*

*NI–16 Clinton Quarry Ltd. (active)*

## REGIONAL GEOLOGY

The regional geology of the Niagara District, for the purpose of this report, will be discussed by quarry distribution which conveniently divides the district into two distinct regions designated as the northern region and the southern region by an east–west line through the City of Welland.

The geomorphology of the northern region of Niagara District is dominated by three main features: the Niagara Escarpment, which trends east–west across the area; Lake Ontario to the north; and the deeply incised Niagara River along the eastern margin of the area. The Escarpment exposes resistant Silurian dolostones and dolomitic limestones, which overlie easily eroded Ordovician shales.

The Upper Ordovician Queenston Formation, represented by olive–green to red, hematitic shales, is the oldest unit in the northern portion of Niagara District. It forms much of the bedrock for the area north of the Escarpment, and has been quarried in places as a clay source. The Queenston Formation is disconformably overlain by the Lower Silurian Cataract Group, represented by the Whirlpool, Cabot Head, and Grimsby Formations (a succession of sandstones, limestones, dolostones, and sandstones with interbedded shales). These units are overlain by the Middle Silurian Clinton Group, a succession of sandstones, limestones, and dolostones with shaly partings, that are represented by the Thorold, Neahga (found only in the eastern margin of the district), Reynales, Irondequoit, Rochester, and the Decew Formations.

The Middle Silurian Lockport Formation overlies the Clinton Group rocks and includes (in ascending stratigraphic order) the following members: the Gasport Member, which consists of medium– to massive–bedded, fossiliferous dolostones and limestones; the Goat Island Member, a thin– to medium–bedded, microcrystalline to very fine–crystalline, cherty dolostone; and the Eramosa Member, a dark, bituminous and fine–crystalline dolostone which is not well exposed in the area. The Vinemount shale beds are found in the northwestern edge of the district near the base of the Eramosa Member.

The overlying Middle Silurian Guelph Formation and the Upper Silurian Salina Formation are present in the subsurface but are not well exposed in this area.

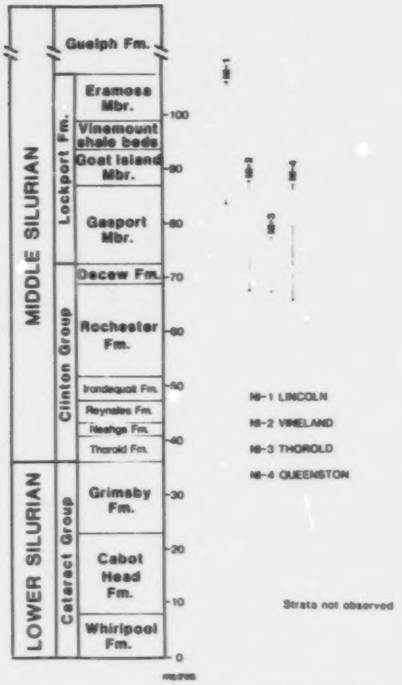
Quarry operations in the northern half of the Niagara Peninsula (see Figure NI–0–2) have concentrated primarily on the Lockport Formation (mainly the Gasport Member). Some abandoned quarries in Clinton Township and three operating quarries (Vineland NI–2, Thorold NI–3, and Queenston Quarries NI–4), have quarried the Decew Formation along with the overlying Gasport Member. The Lincoln Quarry (NI–1), south of Beamsville, is the only operating quarry in the district which utilizes both the Eramosa and Goat Island Members of the Lockport Formation.

All quarries in the northern part of the Niagara District are located along an east–west line parallel to and south of the crest of the Escarpment. The Lockport Formation outcrops in this area that are best suited for quarrying purposes, now lie within Niagara Escarpment Plan Zones which prohibit extraction. Stone from the Lockport Formation is used as aggregate for road construction and concrete, and as a source of building stone.

The southern region of the Niagara District includes all parts of the district south of a line trending east–west through the City of Welland. Geomorphically this is an area of low relief which is dominated by the south and southeastern trending patterns of the Grand River and the discontinuous Onondaga Escarpment. Outcrop exposures are rare because of glacial and lacustrine cover. Limited exposures are located along the Lake Erie shoreline, the Onondaga Escarpment (especially between Clanbrassil and Kohler), and in quarry excavations.

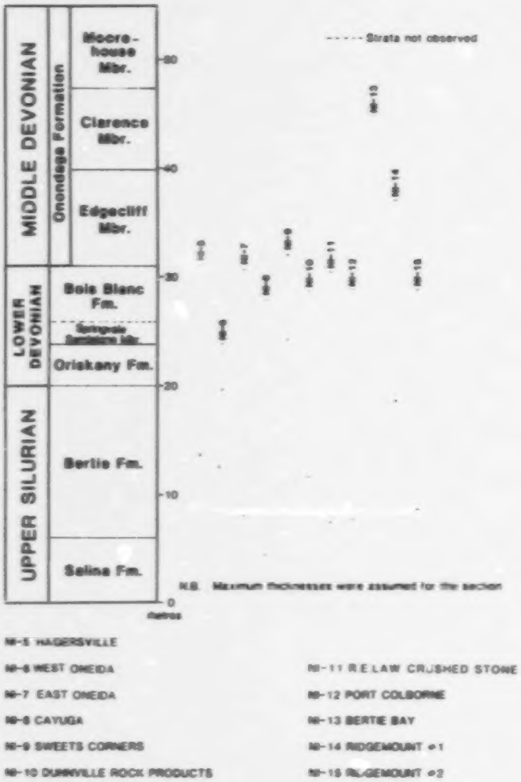
The oldest unit occurring in this area is the Upper Silurian Salina Formation, which consists of argillaceous dolostones with shaly and gypsum partings. The only definite exposure of this unit in the area is found in a roadcut, south of Welland and adjacent to the Welland Canal. Overlying it is the Upper Silurian Bertie Formation which is exposed on the Onondaga Escarpment. This unit, represented by five members (in ascending stratigraphic order; the Oatka, Falkirk, Scajaquanda, Williamsville, and Akron), has lithologies ranging from shaly dolostones to calcareous dolostones and is quarried for various products. The member names are the same as those used in New York State. Individual members are best seen in the eastern portion of the area. The entire Bertie Formation is best seen in the operating Ridgemount Quarries Ltd. Pits 2 and 3 (NI–15).

The top of the Upper Silurian Bertie Formation is a major erosional disconformity (Silurian/Devonian) and it is overlain by the Lower Devonian Bois Blanc Formation. The only known exposures of the Oriskany Formation (an Appalachian Basin unit) in Ontario occur in the extreme southwest corner of the district (near Clanbrassil). In outcrop the Oriskany Formation is a massive, grey to white, medium–grained, friable, fossiliferous, quartz sandstone, but in the subsurface it is difficult to distinguish from the discontinuous Springvale Sandstone Member of the Bois Blanc Formation. In the Cayuga area where the Springvale Sandstone Member is absent, the upper contact of the Oriskany Formation with the Bois Blanc Formation is sharp. The large operating Cayuga Quarry (NI–8), and the smaller quarries NI–6


MIDDLE SILURIAN
LOWER SILURIAN
Lockport Fm.
Clinton Group
Cataract Group
Guelph Fm.
Eramosa Mbr.
Vinemount shale beds
Goat Island Mbr.
Gasport Mbr.
Decew Fm.
Rochester Fm.
Irondequoit Fm.
Reynales Fm.
Neahga Fm.
Thorold Fm.
Grimsby Fm.
Cabot Head Fm.
Whirlpool Fm.
100
90
80
70
60
50
40
30
20
10
0
metres
NI-1
NI-2
NI-3
NI-4
NI-1 LINCOLN
NI-2 VINELAND
NI-3 THOROLD
NI-4 QUEENSTON
Strata not observed

N.B. : Maximum thicknesses have been assumed for this section

Figure NI-0-2. STRATIGRAPHIC COLUMN SHOWING PRINCIPAL QUARRIES IN NORTHERN NIAGARA DISTRICT.


MIDDLE DEVONIAN
LOWER DEVONIAN
UPPER SILURIAN
Onondaga Formation
Moorehouse Mbr.
Clarence Mbr.
Edgecliff Mbr.
Bois Blanc Fm.
Springvale Sandstone Mbr.
Oriskany Fm.
Bertie Fm.
Salina Fm.
50
40
30
20
10
0
metres
----- Strata not observed
NI-5
NI-6
NI-7
NI-8
NI-9
NI-10
NI-11
NI-12
NI-13
NI-14
NI-15
NI-5 HAGERSVILLE
NI-6 WEST ONEIDA
NI-7 EAST ONEIDA
NI-8 CAYUGA
NI-9 SWEETS CORNERS
NI-10 DUNNVILLE ROCK PRODUCTS
NI-11 R.E.LAW CRUSHED STONE
NI-12 PORT COLBORNE
NI-13 BERTIE BAY
NI-14 RIDGEMOUNT #1
NI-15 RIDGEMOUNT #2

N.B. Maximum thicknesses were assumed for the section

Figure NI-0-3. STRATIGRAPHIC COLUMN SHOWING PRINCIPAL QUARRIES IN SOUTHERN NIAGARA DISTRICT.

and NI–7 offer the best exposures of the succession of Bertie, Oriskany and Bois Blanc Formations.

Where present, the Springvale Sandstone Member occupies the basal portion of the Bois Blanc Formation and occurs mainly in the southwestern portion of the district. It consists of a medium– to coarse–grained, green to grey, calcareous, quartz sandstone with interbeds of green glauconitic sandstone, limestone, dolostone and brown chert. The maximum recorded thickness for this member is 2.6 m in the Hagersville quarry (NI–5), although usually it is only observed infilling cracks and joints within the top 2 m of the Bertie Formation. The Springvale Sandstone Member is very irregularly developed and its geographic extent can not be easily delineated.

The Bois Blanc Formation is a cherty limestone with shaly partings which can exhibit a very diverse texture and composition. Locally, it can be quite fossiliferous, and is best exposed in a small abandoned quarry (NI–9), north of Sweets Corners, where a total of 5.4 m of the unit is present. This formation is disconformably overlain by the Middle Devonian Onondaga Formation.

The Onondaga Formation can be subdivided into three members (New York State terminology): the Edgecliff, Clarence, and Moorehouse Members (in ascending order). These three members are restricted to the southern portion of the district. The Edgecliff Member is predominantly a cherty, fossiliferous, bioclastic limestone with shaly partings, and in some areas it can become quite reefal with biohermal and biostromal development. This member is best exposed in the inactive Ridgemount Quarries Ltd. Pit 1 (NI–14) where the upper contact is gradational to the Clarence Member, a massive–bedded, dark grey–brown, fine–crystalline, poorly fossiliferous, very cherty limestone. The distribution of the Clarence Member is controlled by the occurrence of biohermal mounds in the Edgecliff Member. An abandoned quarry, NI–13, near Windmill Point Station, exposes the best stratigraphic sequence of the Clarence Member. The upper contact is gradational to the Moorehouse Member, a brown, fossiliferous, variably cherty limestone. The Moorehouse Member is only seen in outcrop along the Lake Erie shoreline around Cassaday, Pine Crest Point, and Point Abino.

Of the abandoned and operating quarries in the southern portion of the Niagara District (*see* Appendix IV, Volume I), the distribution of eleven of the more significant quarries in the area is illustrated in Figure NI–0–3. The major quarrying operations in the Niagara District have concentrated on the Bertie and Bois Blanc Formations, with minor operations in the Onondaga Formation (Edgecliff and Clarence Members). The six operating quarries in the region utilize the stone for asphalt aggregate and road construction, concrete, and agricultural lime. The Oriskany Formation has been used to produce silica sand.

### LIMESTONE INDUSTRIES

The principal limestone industry in the Niagara District is construction aggregate. Stone production in 1985 and 1986 for the district was approximately 4,170,000 tonnes and 5,168,000 tonnes respectively. The material was used primarily in the construction industry as road and concrete/asphalt aggregate.

Production from quarries within the Regional Municipality of Niagara was 3,115,000 tonnes in 1985 and 4,071,000 tonnes in 1986. Production from the portion of the Regional Municipality of Haldimand–Norfolk which falls within Niagara District amounted to 1,052,000 tonnes in 1985 and 1,097,000 tonnes in 1986.

## NI–1 NELSON AGGREGATE CO. — LINCOLN QUARRY

### LOCATION AND OWNERSHIP

This active quarry, located 6 km south of Beamsville in Lot 20, Concession 9, Town of Lincoln (Clinton Township), Regional Municipality of Niagara, is operated by Nelson Aggregate Co. (Figure NI–1–1). The quarry was opened in 1969 by Aiken and MacLachlan of St. Catharines at a capacity of 900 tonnes per day, a rate that had increased by 1986 to 500,000 tonnes annually over an 8–month operating period. The quarry licence covers an area of 44.53 ha.

### GEOLOGY

The Lincoln Quarry exposes a total of 19.16 m of section from the Lockport Formation (Figure NI–1–2). This includes rocks of the Eramosa and Goat Island Members. The Eramosa Member exposure consists of 8.3 m of a brown, fine–crystalline, medium–bedded, bituminous dolostone. This unit is characterized by very large vugs (up to 1.5 m in diameter) rimmed with calcite crystals. The Goat Island Member is a fine– to medium–crystalline, thin– to massive–bedded, brown dolostone. It is bituminous and richly fossiliferous with abundant stylolites. Mineralization present in the Goat Island Member includes gypsum, sphalerite, calcite, dolomite and chert. Arenaceous zones with sedimentary features are present towards the top of the unit. Overburden is thin, ranging from 15 cm to 90 cm, and is easily removed. The material is currently used to rehabilitate the top bench along the eastern quarry limit.

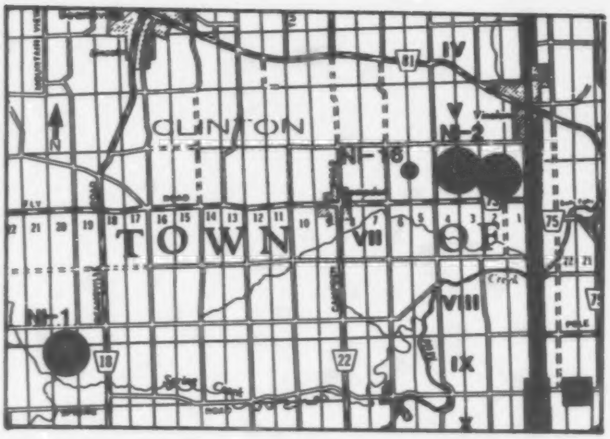


Figure NI–1–1. LOCATION MAP FOR LINCOLN QUARRY.

### Geological Section

*Thickness*

*UNIT 5 Lockport Formation, Eramosa Member* *8.30m*

**Dolostone: brown, weathers brown; fine crystalline; medium bedded (8 to 30 cm), contacts are sharp, slightly undulatory and irregular; calcite crystals rim large vugs (up to 1.5 m in diameter), selenite in pores and vugs; bituminous odor; porous; bryozoa are abundant; stylolitic and bituminous partings present; lower contact is floor of lift #1.**

*UNIT 4 Lockport Formation, Goat Island Member* *3.83m*

**Dolostone: dark grey, weathers grey; sub– to fine and medium crystalline; thin to medium bedded (4 to 15 cm), contacts are sharp and planar; gypsum occurs along fractures, calcite in vugs and pores, dolomite in contorted vugs – some in fractures, red/yellow sphalerite occurs as small nodules; crinoids and brachiopods are abundant as fragments, corals are rare; shaly and silty partings at base with shale rip–ups within the dolostone; the character of the rock changes gradually in the upper 1.40 m to a finer crystalline rock with abundant bituminous stylolites; rock has a lithographic texture; lower contact is sharp, with a 3 cm thick shaly parting.**

*UNIT 3 Lockport Formation, Goat Island Member* *2.83m*

**Dolostone: dark brown, weathers light brown; fine crystalline; massive bedded; stylolitic; calcite in pores, gypsum in fractures and scattered sphalerite mineralization; large stromatoporoids present, abundant algal material in upper part; the upper third of the unit is highly fractured and mineralized; lower contact is sharp.**

*UNIT 2 Lockport Formation, Goat Island Member 1.70m*

Dolostone: dark brown, weathers black-brown; very fine to fine crystalline; thin to medium bedded (4 to 15 cm), sharp contacts with bituminous partings and stylolites; chert, calcite, gypsum and abundant tabulate corals (which can occur in lateral sheets), rare solitary corals, abundant bioturbation (*Chondrites*); bituminous partings present; chert occurs as beds (3 cm thick), black in colour and rimmed with bituminous material; base of unit is quarry floor.

*UNIT 1 Lockport Formation, Gasport Member (in sump) 2.5m*

Dolostone: light brown-buff, weathers tan; fine crystalline; medium to thick bedded, contacts are sharp with black, bituminous partings, some are stylolitic; sphalerite occurs in fractures and on laminae; gypsum, calcite, dolomite and chert (black and tan) mineralization are also present; stromatoporoids and tabulate corals are present; darker laminae occur with bituminous partings.

*Total thickness 19.16m*

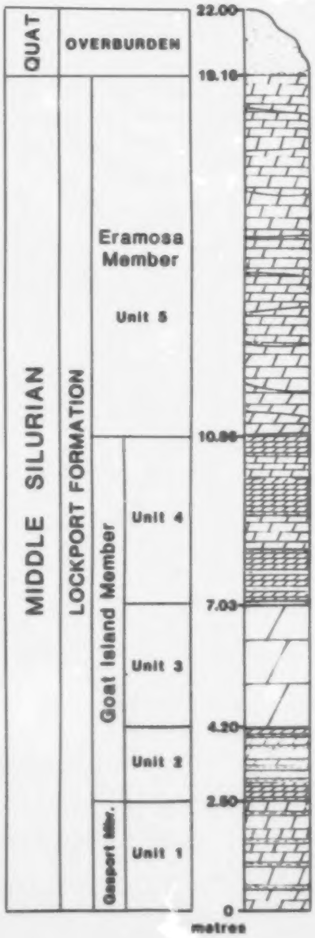


**Figure NI-1-2. STRATIGRAPHIC COLUMN FOR LINCOLN QUARRY.**

### CHEMICAL ANALYSES - 3/4 IN. CONCRETE STONE*

Components in Percent

| | | | |
|---|---|---|---|
| $SiO_2$ | 1.40 | CaO | 29.5 |
| $Al_2O_3$ | 0.96 | L.O.I. | 46.4 |
| $Fe_2O_3$ | 0.52 | Total | 99.28 |
| MgO | 20.5 | $CO_2$ | 45.0 |

* *After Hewitt and Vos, 1972, p. 54.*

### QUARRY OPERATION

Three bench faces are currently exposed to depths of 9 m, 8 m and 4 m, with the future development of a 4th lift projected. Containing low silica (less than 0.5%), the first bench is a high quality stone suitable for metallurgical applications. The second bench has a higher silica content (about 6%) and is used for aggregates.

Blast holes are drilled at 7.6 cm diameter with a Gardner-Denver 3100 air-track on 3.0 m x 3.7 m and 2.4 m x 2.7 m patterns respectively for the first bench and lower two benches. The holes are toe primed with water gel cartridges, loaded with bulk AN/FO and initated with electric caps. Blasting of the lower benches produces some armour stone-sized material that, lacking a ready market, is sorted by a grappler and broken down by a Liebherr backhoe equipped with a hydraulic hammer.

The quarry is dewatered by two 6 in. Flygt electric pumps which supply the twin washing screens. Return water from the screens passes through a series of settling ponds in the quarry before recycling by the Flygt pumps.

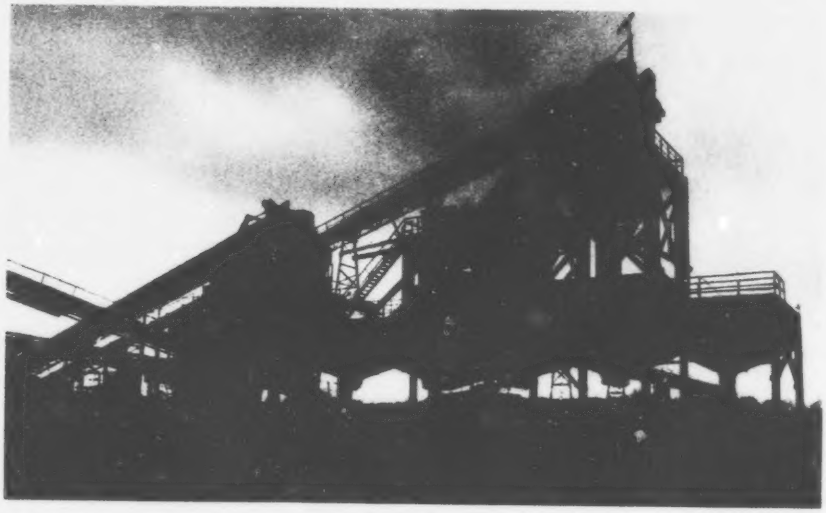
### PROCESSING

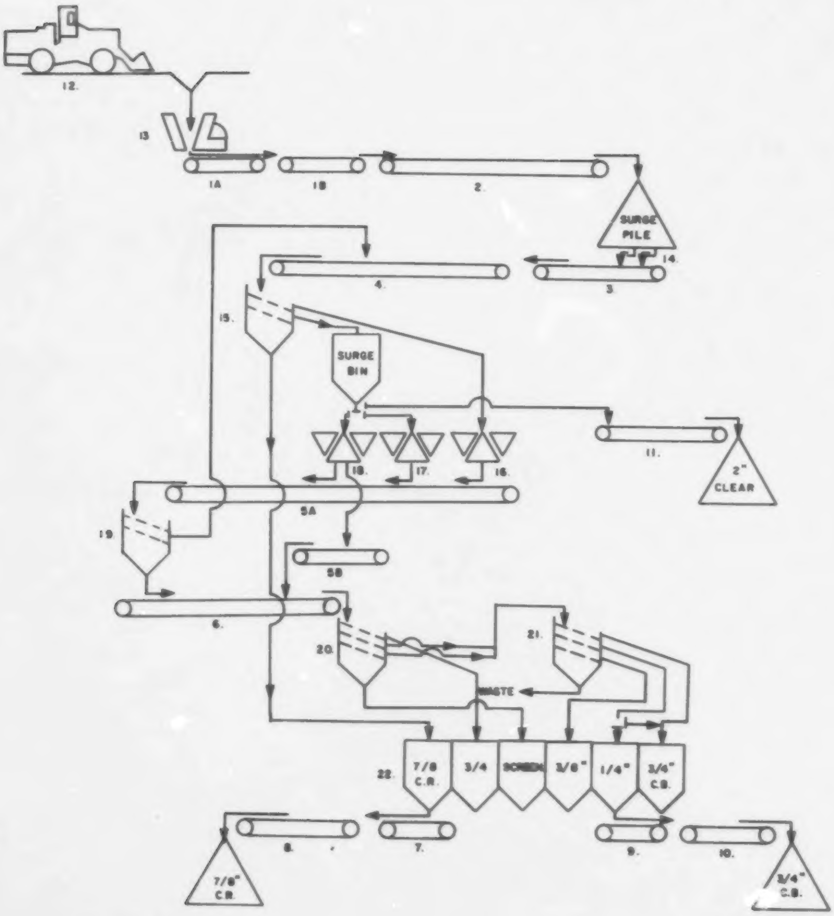
The process flow sheet is shown on Figure NI-1-3. Blasted stone is loaded by one 475 Michigan 12 yd. loader and transported an average 125 m to a portable Cedarapids single impeller primary crusher. The stone is crushed to -7 in. and transported a distance of 500 m by three 36 in. belt conveyors for secondary crushing by 4 ft. and 4 1/4 ft. Symons standard cone crushers. Screening equipment includes two double-deck 5 ft. x 14 ft. Tyrock screens, one single deck 5 ft. x 12 ft. Dillon, two triple-deck 4 ft. x 14 ft. Dillon screens and two triple-deck Cedarapids wash screens. Six bulk bins with approximately 70-tonne storage capacity hold the finer products for truck loadout. Recovery of stockpiled 7/8 in. crusher run and 3/4 in. concrete stone material is by 6.5 yd. 275-B Michigan loader. All products are shipped by truck and are weighed by a 50 ft. truck scale (62.5 tons).

### PRODUCTS

2 in. Clear
3/4 in. Clear
1/2 in. Clear
3/8 in. Clear
1/4 in. Clear
Screenings

**Photo NI-1-1.**
**PROCESSING PLANT AT LINCOLN QUARRY SHOWING SYMONS CONE CRUSHER (LEFT), SCREENS AND BULK LOAD-OUT BINS.**




12.
13
1A
1B
2.
SURGE PILE
14
3.
4.
15.
SURGE BIN
11.
2" CLEAR
18.
17.
16.
5A
19.
5B
6.
20.
21.
WASTE
22.
7/8 C.R.
3/4
SCREEN
3/8"
1/4"
3/4" C.B.
8.
7.
9.
10.
7/8" C.R.
3/4" C.B.

CONVEYOR LIST

1A - 36" x 504'
1B - 36" x 450'
2 - 36" x 650'
3 - 36" x 80'
4 - 36" x 130'
5A - 30" x 120'
5B - 30" x 90'
6 - 30" x 195'
7 - 24" x 90'
8 - 24" x 60'
9 - 24" x 200'
10 - 24" x 150'
11 - 30" x 80'

EQUIPMENT LIST

12 - Front End Loader
13 - Cedarapids 43"x 40" Primary Crusher
14 - Mod F55 Syntron Feeder
15 - 2 5' x 12' Tyrock Double Deck Screens
16 - 4¼' Symons Std. Cone Crusher
17 - 4' Symons Std. Cone Crusher
18 - Barmac Rotopactor Crusher
19 - 1 5'x16' Dillon Single Deck Screen
20 - 2 4'x14' Dillon Triple Deck Screen
21 - 2 4'x14' Cedarapids Triple Deck Screen
22 - Truck Loading Bins

**Figure NI-1-3. PROCESS FLOW SHEET FOR LINCOLN QUARRY.**

7/8 in. Crusher Run
Asphalt Stone
Agricultural Lime

### REFERENCES

Hewitt and Vos, 1972, p.54
ARIP 104, 1985, p.20 (Q1)

### MAPS

Liberty, Feenstra and Telford, 1976b, ODM Map 2344

## NI-2 VINELAND QUARRIES AND CRUSHED STONE LTD. — VINELAND QUARRY

### LOCATION AND OWNERSHIP

This active quarry is located near the edge of the Niagara Escarpment south of Vineland in Lots 1, 2, 3 and 4, Concessions 6 and 7, Town of Lincoln (Clinton Township), Regional Municipality of Niagara (Figure NI–2–1). Vineland Quarries and Crushed Stone Ltd. is owned by Walker Industries Holdings Ltd., the present operator. The quarry licence covers an area of 165.1 ha. Part of Vineland Quarry's annual production is derived from blasted stone supplied from the adjacent Clinton Quarry (NI–16). The Vineland crushing facilities are forecast to become increasingly dependent on the Clinton Quarry (also owned by Walker Industries), for a supply of feed stone.

### GEOLOGY

The Vineland Quarry exposes a total of 8.95m of section which consists of Middle Silurian rocks from the Rochester and Decew Formations, and from the Goat Island and Gasport Members of the Lockport Formation (Figure NI–2–2). The basal Rochester Formation consists of 0.30 m of shaly dolostone which is overlain by the Decew Formation, 1.22 m of a fine–crystalline, massive–and irregular– bedded dolostone. The Lockport Formation exposure consists 7.43 m of a medium– to coarse–crystalline, fossiliferous dolostone (Gasport Member) and a subcrystalline, massive dolostone representing the Goat Island Member. The quarry is large and the working face is being extended westward.

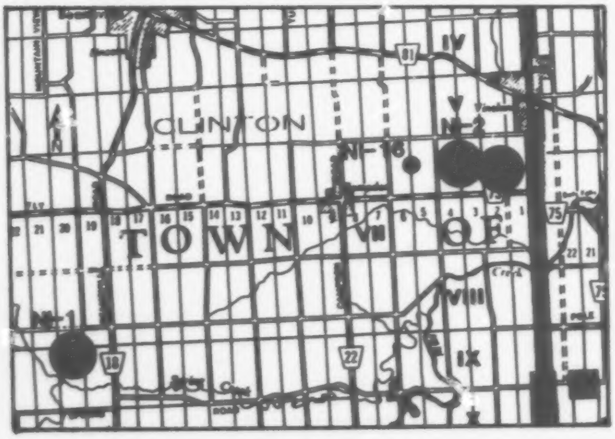


**Figure NI-2-1. LOCATION MAP FOR VINELAND QUARRY.**

### Geological Section

| | | Thickness |
|---|---|---|
| *UNIT 5* | *Lockport Formation, Goat Island Member* | *1.70m* |

Dolostone: pinkish-brown, weathers buff; fine crystalline; massive bedded with irregular contacts; stylolitic and sucrosic; weathers vuggy and pocked; this unit is only found on the east side of the quarry; lower contact is sharp and undulatory.

| | | |
|---|---|---|
| *UNIT 4* | *Lockport Formation, Gasport Member* | *2.40m* |

Dolostone: light brown to cream, weathers buff; medium crystalline; massive bedded with irregular contacts; very porous and stylolitic; quite fossiliferous with abundant crinoids; sharp lower contact.

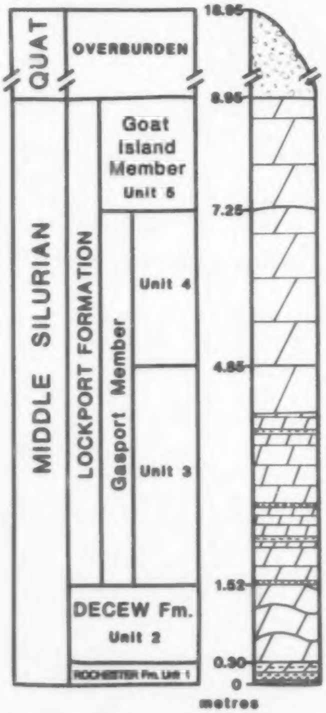


**Figure NI-2-2. STRATIGRAPHIC COLUMN FOR VINELAND QUARRY.**

**Photo NI-2-1.**
**QUARRY SECTION SHOWING GASPORT MEMBER OF THE LOCKPORT FORMATION OVERLYING THE DECEW FORMATION; VINELAND QUARRY.**

*UNIT 3 Lockport Formation, Gasport Member* *3.33m*

Dolostone: dark grey-brown, weathers buff-grey; medium to coarse crystalline; medium to thick bedded, contacts are sharp and irregular, some beds are laminated; lower 48 cm is a crinoidal dolostone with shaly interbeds; upper 2.85 m is more massive, coarse crystalline and not as shaly; dolomite mineralization replaces fossil debris, gypsum occurs as nodules, and calcite is present in vugs; very fossiliferous throughout (bryozoa, brachiopods and crinoids); some rip-up clasts present at the base; rare bituminous partings; lower contact is sharp.

*UNIT 2 Decew Formation* *1.22m*

Dolostone: dark grey-brown, weathers light grey-brown; fine crystalline; thick bedded with contorted contacts; mottled appearance with contorted laminae; calcite crystals rim vugs, as does gypsum; some slumping features present; sharp lower contact.

*UNIT 1 Rochester Formation* *0.30m*

Interbedded shaly dolostone and dolomitic shales: black-grey, weathers black; very fine to fine crystalline; thin to medium bedded (5 to 25 cm), contacts are sharp and laminated; gypsum filled vugs are abundant; some sedimentary features; rare gastropods present, abundant burrows (*Chondrites*) on bedding planes.

*Total thickness* *8.95m*

## QUARRY OPERATION

The quarry is worked on two lifts totalling 9 m. Blasthole drilling is carried out with a Gardner–Denver 123 drill, on a 2.7 m x 2.7 m pattern with 7.6 cm diameter holes. The blasting conditions are dry and prilled ammonium nitrate is used as a bulk explosive. The blasted stone is transferred by a Caterpillar 992B loader to three 50–ton Euclid trucks for haulage to the primary crusher.

## PROCESSING

The process flow sheet is shown on Figure NI–2–3. The primary crusher, a Jeffrey 536 impact unit, reduces the stone to –8 in. which is then fed by a 48 in. conveyor to a 6 ft. x 16 ft. double–deck screen. The screen produces Granular "A" and +4 in. –6 in. rubble rock, both of which are stockpiled by conveyor, and –8 in. material that is carried to a surge pile by a 42 in. conveyor. The surge pile material is recovered by a vibrating feeder onto a 36 in. tunnel conveyer that feeds a second 6 ft. x 16 ft. double–deck screen. This screen produces +1 1/2 in. oversize that is sent to a Symons 5 1/2 ft. cone crusher, –1 1/2 in. and +7/8 in. material sent to either a Penn or Jeffrey impact crusher, and –1/2 in. fines that are added to the output of the Symons cone crusher and fed to another 6 ft. x 16 ft. double–deck screen. This screen produces 3/4 in. clear, –5/8 in. granular stone and screenings. Stone crushed by the two impactors is screened by two parallel 7 ft. x 20 ft. double–deck screens that return +3/4 in. oversize for recrushing and feed the –3/4 in material to an 8 ft. x 22 ft. double–deck screen. This screen produces –3/4 in. +1/2 in. concrete stone and –1/2 in. material that is split by a 5 ft. x 12 ft. screen into –1/2 in. +3/16 in. chips and –1/4 in. screenings.

## PRODUCTS

Vineland Quarries and Crushed Stone Ltd. has the capability to produce different grades of concrete, asphalt

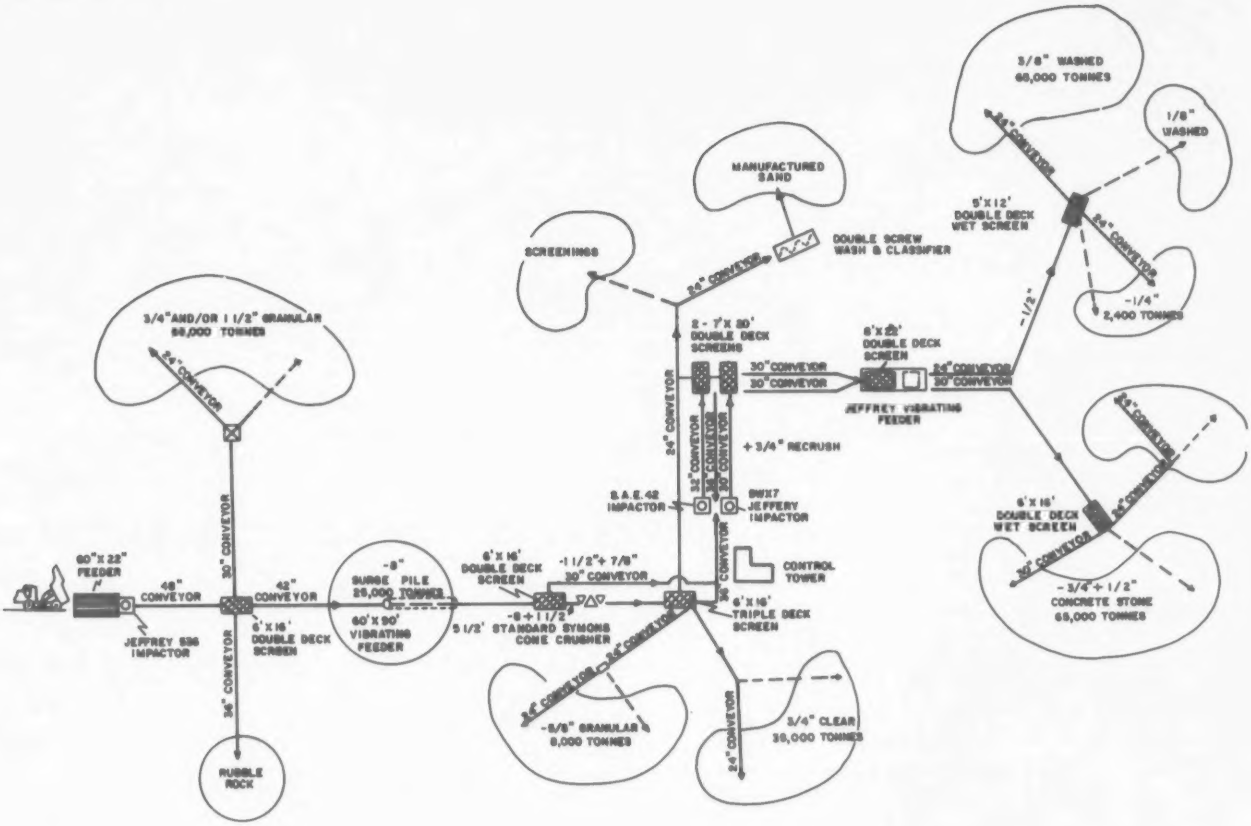

3/4" AND/OR 1 1/2" GRANULAR
60,000 TONNES
24" CONVEYOR
30" CONVEYOR
60" X 22" FEEDER
48" CONVEYOR
JEFFREY 536 IMPACTOR
42" CONVEYOR
6' X 16' DOUBLE DECK SCREEN
36" CONVEYOR
RUBBLE ROCK
-8"
SURGE PILE
25,000 TONNES
60' X 90' VIBRATING FEEDER
6' X 16' DOUBLE DECK SCREEN
-1 1/2" + 7/8"
30" CONVEYOR
-8 + 1 1/2"
5 1/2' STANDARD SYMONS CONE CRUSHER
24" CONVEYOR
24" CONVEYOR
-5/8" GRANULAR
8,000 TONNES
6' X 16' TRIPLE DECK SCREEN
CONTROL TOWER
36" CONVEYOR
24" CONVEYOR
3/4" CLEAR
38,000 TONNES
S.A.E. 42 IMPACTOR
8WX7 JEFFERY IMPACTOR
32" CONVEYOR
36" CONVEYOR
30" CONVEYOR
+ 3/4" RECRUSH
24" CONVEYOR
2 - 7' X 20' DOUBLE DECK SCREENS
SCREENINGS
24" CONVEYOR
MANUFACTURED SAND
DOUBLE SCREW WASH & CLASSIFIER
30" CONVEYOR
30" CONVEYOR
8' X 22' DOUBLE DECK SCREEN
JEFFREY VIBRATING FEEDER
24" CONVEYOR
30" CONVEYOR
-1/2"
5' X 12' DOUBLE DECK WET SCREEN
3/8" WASHED
65,000 TONNES
24" CONVEYOR
1/8" WASHED
24" CONVEYOR
-1/4"
2,400 TONNES
6' X 16' DOUBLE DECK WET SCREEN
24" CONVEYOR
30" CONVEYOR
30" CONVEYOR
-3/4" + 1/2"
CONCRETE STONE
65,000 TONNES

Figure NI-2-3. PROCESS FLOW SHEET FOR VINELAND QUARRY.

and crusher run stone by varying the screen sizes including but not restricted to, the following:

Rubble Rock
1 1/2 in. Granular
3/4 in. Granular
–5/8 in. Granular
3/4 in. Clear
Screenings
Manufactured Sand
3/8 in. Washed
1/8 in. Washed
–1/4 in. Washed
–3/4 in. + 1/2 in.
  Concrete Stone

### REFERENCES

Hewitt, 1960, p.98–99
Hewitt and Vos, 1972, p.55–56
ARIP 104, 1985, p.20

### MAPS

Liberty, Feenstra and Telford, 1976b, ODM Map 2344

## NI–3 WALKER BROTHERS QUARRIES LTD. — THOROLD QUARRY

### LOCATION AND OWNERSHIP

The Walker Brothers Quarry is owned and operated by Walker Industries Holdings Limited and is located on the brow of the Niagara Escarpment, 2 km east of Thorold in Lots 11, 30, 31, 49, 50 and 66, City of Niagara Falls (Stamford Township) and Lots 43, 44 and 45 in the City of Thorold, Regional Municipality of Niagara (Figure NI–3–1). The quarry licence covers an area of 171.9 ha.

Walker Brothers celebrated their one hundredth anniversary in 1987. Early operations were confined to stone cutting, followed in 1893 by a shift to stone crushing. Walker Brothers have provided cut stone for such structures as the Chatham Armory, the Toronto Armory and the Welland Canal. In the early years of the twentieth century many pulp and paper producers relied on

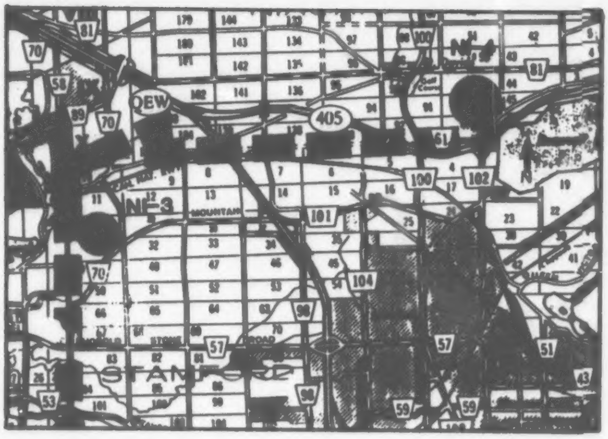


Figure NI-3-1. LOCATION MAP FOR THOROLD QUARRY.

crushed stone from the Thorold Quarry to facilitate their chemical processes. The first fully mechanized crushed stone plant, with a 250 ton per hour capacity, was built at the Thorold Quarry in 1947. Concrete aggregate was supplied for the construction of the Queen Elizabeth Way and the Skylon Tower in Niagara Falls.

## GEOLOGY

The Thorold Quarry exposes 9.78 m of section: 0.88 m from the Rochester Formation, 3.0 m from the Decew Formation, and 5.9 m from the Gasport Member of the Lockport Formation (Figure NI-3-2). The Rochester Formation is typically an interbedded dolomitic shale and shaly dolostone, whereas the Decew is a fine-crystalline, irregular-bedded, fossiliferous dolostone. The Gasport Member is a massive-bedded fossiliferous dolostone. The thickness of the Decew Formation is variable and ranges from 0.0 to 3.0 m along the quarry face.

### Geological Section

*Thickness*

*UNIT 3 Lockport Formation, Gasport Member* *5.9m*

**Dolostone: pink-grey, weathers tan-buff; fine to coarse crystalline (fines upwards); medium to thick bedded, contacts are sharp but very irregular, unit becomes medium bedded at the top; some beds appear biohermal at the top of the unit; stylolites present; dolomite, sphalerite, and calcite mineralization present; a 10 to 15 cm bed at the base is a fine crystalline, green-grey, shaly, glauconitic dolostone, its upper contact to the Gasport is sharp; lower contact with the Decew is sharp and undulatory.**

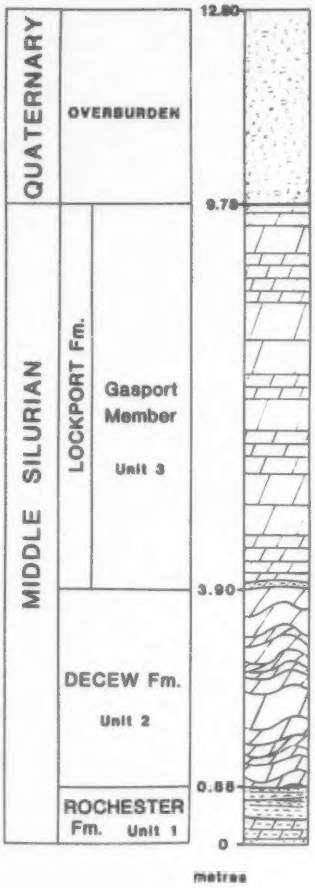


Figure NI-3-2. STRATIGRAPHIC COLUMN FOR THOROLD QUARRY.

*UNIT 2 Decew Formation* *3.0m*

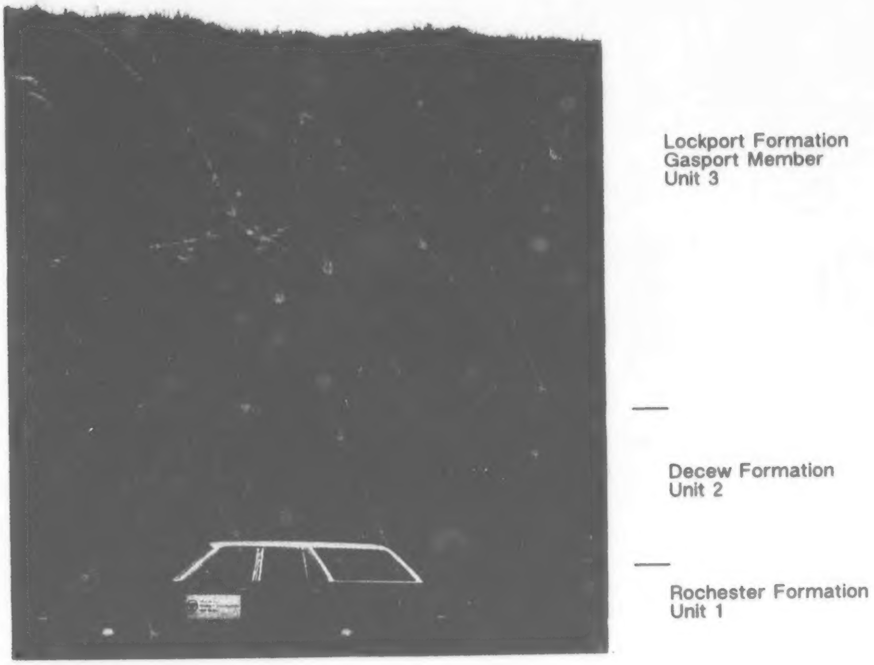
**Dolostone: medium to dark grey, weathers dark tan to rust; fine crystalline; very irregularly bedded, beds pinch and swell, and are contorted with a hummocky appearance; lower 0.5 m is sucrosic, vuggy and porous, and displays some soft sediment deformation with debris; lower contact is sharp with bituminous and clayey partings, scouring occurs into the underlying units; lower contact is sharp.**

*UNIT 1 Rochester Formation* *0.88m*

**Interbedded dolomitic shale and shaly dolostone: black to dark grey, weathers black; sub- to fine crystalline; thin to medium bedded (3 to 30 cm), contacts are sharp and slightly undulatory, beds are quite laminated; rare gypsum occurs in vugs; scattered clay seams and bituminous partings.**

*Total thickness* *9.78m*

Photo NI-3-1. TYPICAL SECTION AT THOROLD QUARRY.


Lockport Formation
Gasport Member
Unit 3
Decew Formation
Unit 2
Rochester Formation
Unit 1

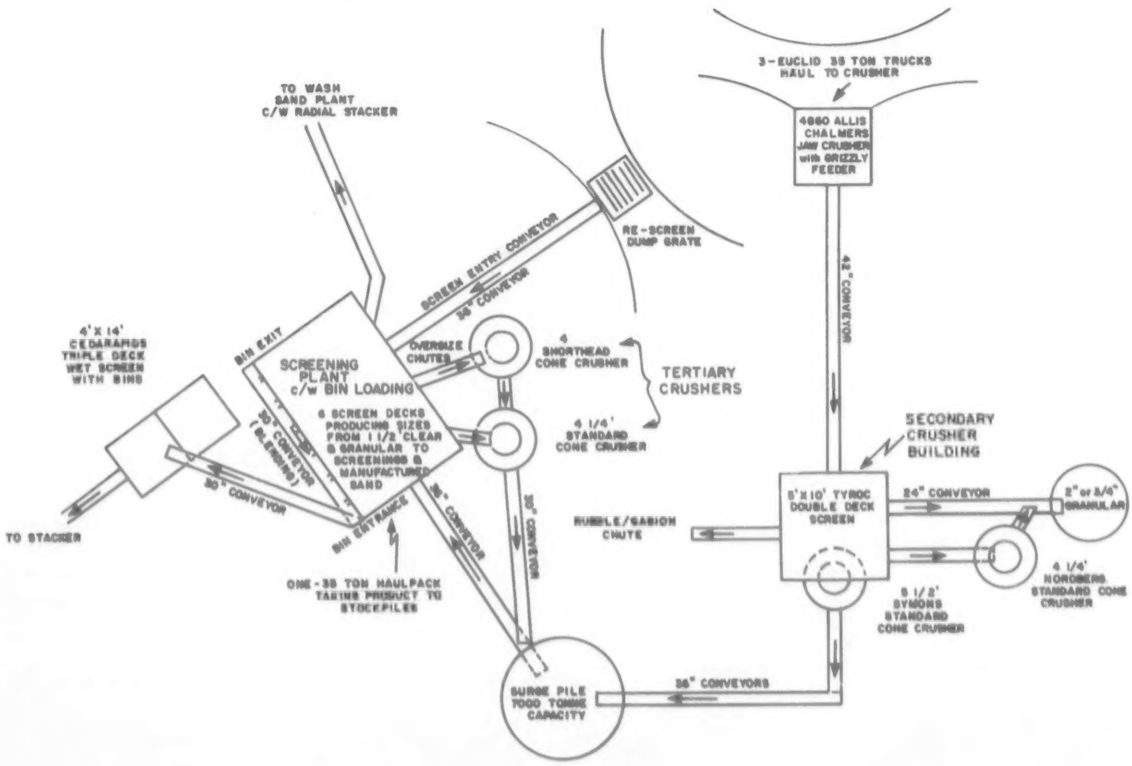

3-EUCLID 35 TON TRUCKS HAUL TO CRUSHER
4860 ALLIS CHALMERS JAW CRUSHER with GRIZZLY FEEDER
42" CONVEYOR
SECONDARY CRUSHER BUILDING
5'X10' TYROC DOUBLE DECK SCREEN
24" CONVEYOR
2" or 3/4" GRANULAR
4 1/4' NORDBERG STANDARD CONE CRUSHER
5 1/2' SYMONS STANDARD CONE CRUSHER
RUBBLE/GABION CHUTE
36" CONVEYORS
SURGE PILE 7000 TONNE CAPACITY
TO WASH SAND PLANT C/W RADIAL STACKER
RE-SCREEN DUMP GRATE
SCREEN ENTRY CONVEYOR
36" CONVEYOR
4 SHORTHEAD CONE CRUSHER
TERTIARY CRUSHERS
4 1/4' STANDARD CONE CRUSHER
OVERSIZE CHUTES
BIN EXIT
SCREENING PLANT c/w BIN LOADING
6 SCREEN DECKS PRODUCING SIZES FROM 1 1/2 CLEAR & GRANULAR TO SCREENINGS & MANUFACTURED SAND
30" CONVEYOR (BLENDING)
30" CONVEYOR
36" CONVEYOR
30" CONVEYOR
BIN ENTRANCE
ONE-35 TON HAULPACK TAKING PRODUCT TO STOCKPILES
4'X14' CEDARAPIDS TRIPLE DECK WET SCREEN WITH BINS
TO STACKER

Figure NI-3-3. PROCESS FLOW SHEET FOR THOROLD QUARRY.

### QUARRY OPERATION

A single 8.9 m lift is drilled by a Gardner–Denver Hydratrac on a 2.75 x 2.75 m pattern with 7.6 cm diameter holes. The blasting agents are Powermex 300 and prilled ammonium nitrate, initiated with electric caps. A Cat 988B loader transfers the blasted stone from the face into 3 Euclid R35 trucks for haulage to the primary crusher.

### PROCESSING

The process flow sheet is shown on Figure NI–3–3. The blasted stone is dumped onto a grizzly that feeds an Allis–Chalmers 4860 jaw crusher. The crushed stone is conveyed to a 5 1/2 ft. Symons standard cone in the Secondary Crusher Building, producing 2 in. to 3/4 in. granular stone or feeding a surge pile. Stone from the surge pile is conveyed to the screening plant where stone sizes from 1 1/2 in. clear and 1 1/2 in. granular to screenings and manufactured sand are produced. Oversize from different screens is recrushed in either a 4 ft. shorthead cone or a 4 1/4 ft. standard cone and returned to the surge pile. The screening plant products can be blended as required or sent to twin washing screens.

### PRODUCTS

The Walker Brothers Thorold Quarry produces a variety of products ranging from Gabion stone, to 1 1/2 in. clear and granular, to screenings and manufactured sand.

### REFERENCES

Goudge, 1938, p.278–279

Hewitt, 1960, p.95–95

Hewitt, 1964a, p.43

Hewitt and Vos, 1972, p.56

### MAPS

Caley, 1941c, GSC Map 584A

Liberty, Feenstra and Telford, 1976b, ODM Map 2344

## NI-4 STEETLEY INDUSTRIES LTD. – QUEENSTON QUARRY

### LOCATION AND OWNERSHIP

This large operating quarry in Lots 44, 45, 47, 48 and 49, Town of Niagara–on–the–Lake (Niagara Township), Regional Municipality of Niagara, is 3 km west of the town of Queenston (Figure NI–4–1). The licensed area of the quarry is 157.48 ha.

Extraction from the Queenston Quarry site began in 1837 with the development of a small building stone quarry. Material from this quarry was used for construction of the Grand Trunk Railway and later in 1874 for the locks of the Welland Canal. By 1892 seven small quarries occupied the site of the present large quarry. Also by this time, material from these quarries was being utilized in the manufacturing of cement.

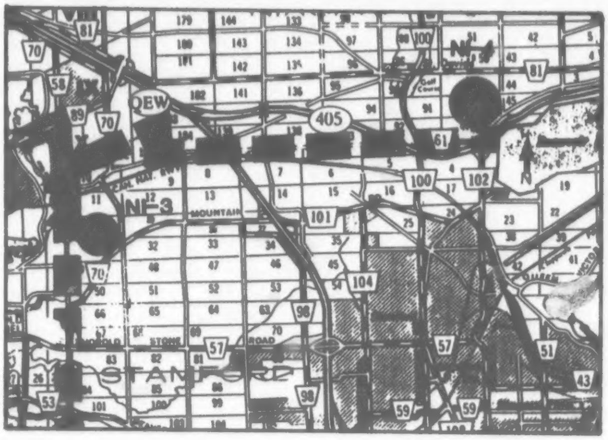


Figure NI-4-1. LOCATION MAP FOR QUEENSTON QUARRY.

The distinctive "blue" dolostone quarried from the Gasport Member of the Lockport Formation at this site was extensively used for monument bases and shafts and for the construction of post offices in Cornwall, Niagara Falls and St. Catharines.

### GEOLOGY

The quarry exposes 9.7 m of Middle Silurian strata (Figure NI–4–2). At the base of the quarry, 2.4 m of the Rochester Formation is exposed and consists of interbedded shaly dolostones and dolomitic shales. The Rochester is sharply overlain by the Decew Formation (1.5 m) which is a medium to thickly bedded, undulatory and contorted dolostone. Above the Decew Formation, 0.65 m of a conglomeratic, shaly dolostone occurs, which is transitional between the Decew and the Gasport Member of the Lockport Formation. This lithology is distinctively green, glauconitic, very fossiliferous, and both the upper and lower contacts are erosional.

The Gasport Member (Lockport Formation) caps the transitional zone, and is typically a massive bedded, crinoidal dolostone (4.37 m thick). It is overlain by 0.75 m of the Goat Island Member from the Lockport Formation and consists of thin– to medium–bedded, fine–crystalline dolostone. Overburden cover is approximately 4 m.

## Geological Section

*Thickness*

*UNIT 5 Lockport Formation, Goat Island Member 0.75m*

Dolostone: dark grey, weathers tan; fine crystalline; thin to medium bedded, contacts are sharp, slightly undulatory, but laterally continuous; sucrosic; chert and dolomite mineralization present in vugs; crinoidal debris abundant in lower 2 to 3 m; sharp lower contact.

*UNIT 4 Lockport Formation, Gasport Member 4.37m*

Crinoidal dolostone: blue to green-grey, weathers grey-rust to brown; fine to medium crystalline; massively bedded (average 2 m), contacts are sharp and stylolitic (up to 5 cm thick) with undulatory partings; draping of beds are present; one meter above the base, a 1 cm thick glauconitic shale bed exists which is laterally discontinuous; scattered irregular shale beds are present; dolomite, calcite and sphalerite mineralization present in vugs; some bituminous residue and iron staining also present; very fossiliferous with abundant crinoids and coralgal debris and material, rare brachiopods; upper 2 m of the unit possesses abundant coralgal debris and vugs; lower contact is sharp.

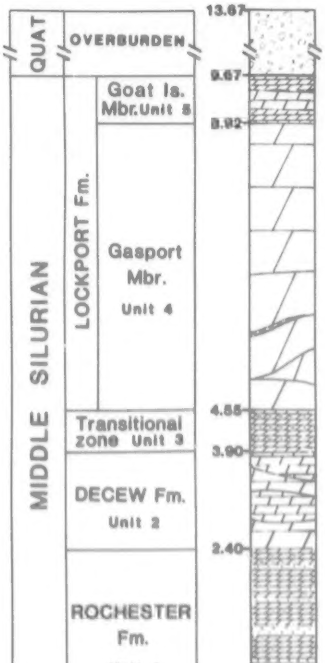


Figure NI-4-2. STRATIGRAPHIC COLUMN FOR QUEENSTON QUARRY.

*UNIT 3 Transitional Zone: Lockport Formation (Gasport Member) and Decew Formation 0.65m*

Conglomeratic and shaly dolostone: dark grey to green, weathers same; coarsely crystalline; thinly bedded, becomes medium bedded at top of unit; very fossiliferous (abundant crinoids); abundant rip-up clasts from the underlying shaly dolostone, clasts are up to 5 cm long, angular and oriented parallel to bedding; shaly dolostone is 25 to 35 cm thick and occurs at the base of the unit; top contact is sharp and erosional; finely crystalline; thinly bedded and laminated; glauconitic; occurs in hollows of the underlying Decew Formation; abundant insoluble residue seams (approximately 1 mm thick); sharp lower contact.

*UNIT 2 Decew Formation 1.50m*

Dolostone: dark grey, weathers grey to tan; sub- to fine-crystalline; medium to thick bedded (10-60 cm); contacts are sharp and very undulatory; beds pinch and swell with contorted laminae; some crenaceous zones are present; some bituminous dark grey partings present (up to 4 cm thick); sphalerite mineralization occurs in pores; crinoids abundant as fossil debris; sharp, scoured lower contact.

*UNIT 1 Rochester Formation 2.40m*

Interbedded shaly dolostones and dolomitic shales: grey to black, weathers black; sub- to fine-crystalline; thin bedded and laminated, contacts are irregular; possesses a bituminous odour.

*Total thickness 9.67m*

## QUARRY OPERATION

The following description of the Queenston Quarry operation was prepared from information provided by Steetley Industries Ltd. The quarry site was not visited at the owner's request.

The current reserves and quarry area comprise approximately 100 ha. The overburden thickness on the property is moderately variable ranging from 5.5 to 7.5 m which results in a 1:1 stripping ratio. The quarry is being developed on two benches with the production coming from one 7.5 m and one 3.5 m working face. Surface run off and ground water seepage is controlled at one internal and one external pumping station by one 4 in. and one 6 in. submersible pump, respectively.

The stone is quarried by drilling and blasting. An Ingersoll-Rand airtrac is used to drill 7 cm diameter holes in a 2 m x 2 m blasting pattern. A CIL high explosive with ammonium nitrate is used as the blasting agent. Secondary breaking at the face is accomplished with a drop ball.

At the quarry face, the broken rock is loaded by a VME 320 8 yd. front end loader into a 22-tonne Terex truck and delivered to the processing plant a maximum haul distance of 215 m.

## PROCESSING

The quarry run material is dumped into a Pioneer 35 in. x 46 in. primary jaw crusher. The throughput is further reduced by two 4 1/4 in. secondary cone crushers and conveyed to a screening tower where three Tyrock dou-

Lockport Formation
Goat Island Member
Unit 5
Gasport Member
Unit 4

**Photo NI-4-1. TYPICAL SECTION AT QUEENSTON QUARRY.**

ble–deck screens produce a variety of sized products as required. The screened material is conveyed to 8 sized stockpiles.

### PRODUCTS

The product sizes were not disclosed by Queenston Quarries but would probably include a wide range of products from Gabion stone to 1 1/2 in. clear and granular, to screenings and manufactured sand.

### REFERENCES

Blair, 1965, p.49–50
Goudge, 1938, p.251–254
Hewitt, 1960, p.91–94
Hewitt, 1964b, p.2–7
Hewitt, 1964a, p.43
Hewitt and Vos, 1972, p.55

### MAPS

Caley, 1941c, GSC Map 584A
Liberty, Feenstra and Telford, 1976b, ODM Map 2344

## NI–5 STANDARD AGGREGATES INCORPORATED — HAGERSVILLE QUARRY

### LOCATION AND OWNERSHIP

The Hagersville Quarry is located on the northeastern outskirts of the town of Hagersville in Lots 28 and 29, Range east of Plank Rd., Town of Haldimand (Oneida Township), Regional Municipality of Haldimand–Norfolk (Figure NI–5–1). This quarry began operation in the 1920s and is owned and operated by Standard Aggregates Inc. (Division of Standard Industries). At present, extraction is from the quarry south of the railway line and the plant equipment (crusher, etc.) is located in the depleted portion of the quarry north of the railway. The

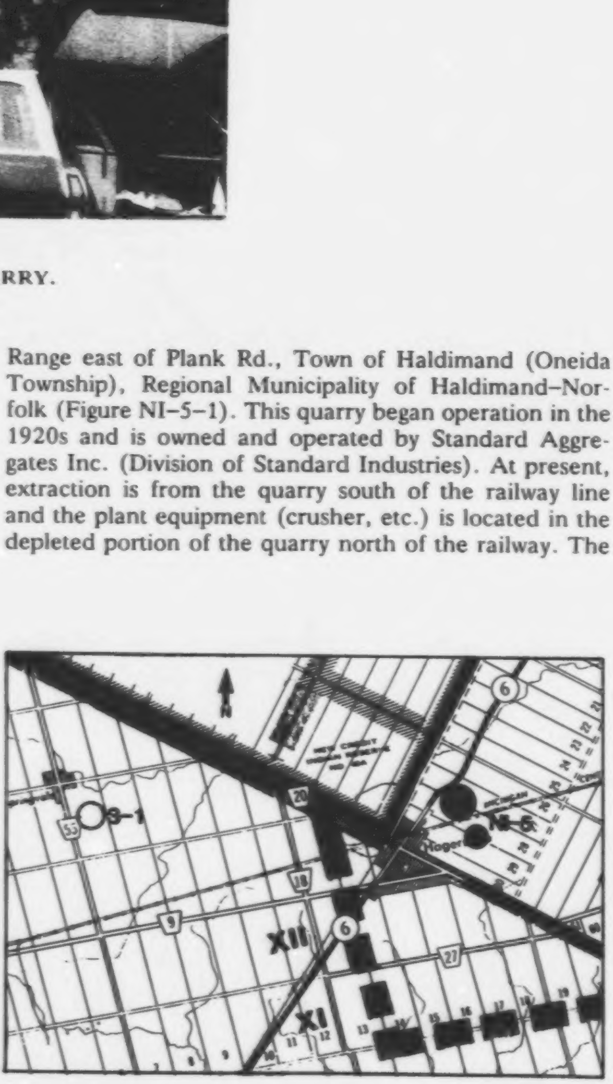


**Figure NI–5–1. LOCATION MAP FOR HAGERSVILLE QUARRY.**

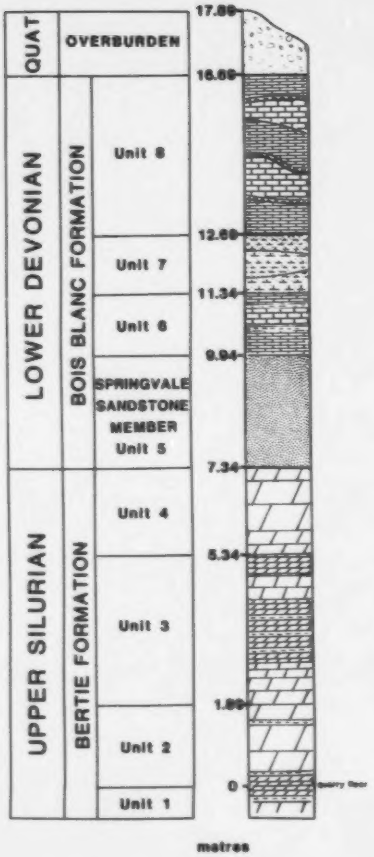


**Figure NI-5-2. STRATIGRAPHIC COLUMN FOR HAGERSVILLE QUARRY.**

quarry operates under two licences for 42.10 ha and 43.34 ha.

## GEOLOGY

In the Hagersville Quarry, a total of 16.39 m of Upper Silurian Bertie Formation and Lower Devonian Bois Blanc Formation is exposed (Figure NI-5-2). The Bertie Formation exposure is 7.34 m of various lithologies including dolostones, bituminous dolostones and shaly dolostones. Some are very brecciated and laminated in places. The top contact with the Bois Blanc is sharp and contains fractures infilled with glauconitic sandstone and represents a major unconformity. The base of the Bois Blanc Formation contains 2.6 m of this sandstone, assigned to the Springvale Sandstone Member. Overlying this unit are typical cherty, fossiliferous limestones from the Bois Blanc Formation. There is some paleontological evidence to suggest the upper 2.3 m of the quarry is Onondaga Formation (Edgecliff Member) although a lithological contact is not evident. The overburden cover is 1.0 to 1.5 m thick.

### Geological Section

| | | Thickness |
|---|---|---|
| *UNIT 8* | *Bois Blanc Formation* | *3.70m* |

Cherty, fossiliferous limestone: cream-grey, weathers tan; fine crystalline; thin to medium bedded with sharp, thin shaly contacts; beds pinch and swell and are contorted; calcarenite beds occur at the base; grey to dark grey chert replaces fossils; minor pyrite mineralization present; very fossiliferous with abundant rugose corals, colonial corals and bryozoans; very bioclastic zones occur throughout; lower contact is sharp.

*UNIT 7 Bois Blanc Formation* *1.35m*

Calcarenite: cream-grey, weathers same; fine to medium grained; thin bedded (5 to 10 cm), contacts are sharp and undulatory; grey chert appears in upper horizons; becomes finer grained at the top; lower contact is sharp.

*UNIT 6 Bois Blanc Formation* *1.40m*

Cherty limestone: buff-brown, weathers buff-grey; very fine crystalline; fine to medium bedded (less than 15 cm), contacts are sharp with fine black shaly partings; blue-grey chert occurs as lenses and contorted beds; abundant bryozoans; abundant pyrite in shaly partings; lower contact is sharp.

*UNIT 5 Bois Blanc Formation, Springvale Sandstone Member* *2.60m*

Glauconitic sandstone: green, weathers grey-green; fine to medium grained; one massive bed; lower contact is sharp and disconformable.

*UNIT 4 Bertie Formation* *2.00m*

Dolostone: light grey to tan, weathers light buff to tan; sub- to fine-crystalline; medium to thick bedded, contacts are irregular and beds are not laterally extensive; glauconitic sand occurs as clasts and lenses in upper part of unit; chert appears as nodules, lenses, and discontinuous beds; lower contact is sharp.

*UNIT 3 Bertie Formation* *3.45m*

Bituminous dolostone: dark brown to medium grey, weathers dark brown; fine crystalline; thin to medium bedded, contacts are sharp with bituminous partings; banded and laminated; three grey-black shale interbeds present; bituminous material occurs in fractures; lower contact is sharp.

*UNIT 2 Bertie Formation* *1.89m*

Dolostone, with some bituminous shale: grey to dark brown, weathers same; very fine to medium crystalline; mainly thick bedded with some thinner beds, contacts are indistinct and have bituminous and stylolitic partings; dolostones display "birdseye" structures; overall unit is very laminated and mottled; some brecciation present with rip-up clasts; more calcarenaceous in places; rare pyrite and chalcopyrite mineralization; mud cracks present on shale partings; sharp lower contact.

*UNIT 1 Bertie Formation* *quarry floor*

Interbedded dolostones and shales: blue-grey shale and grey-brown dolostone, weathers same; fine crystalline; thin to medium bedded with sharp contacts; shales are very friable; pyrite present on shale beds; some bioturbation on bedding planes.

*Total thickness* *16.39m*

Bois Blanc Formation
Unit 8
⇑
Unit 5

Photo NI-5-1. TYPICAL SECTION OF BOIS BLANC FORMATION AT HAGERSVILLE QUARRY.

## QUARRY OPERATION

Operating eight months per year, the nominal annual capacity of the Hagersville Quarry is 350,000 tonnes. The quarry has been mined on two lifts of 9 m and 7.4 m over an area of approximately 17 ha. The upper lift is a cherty formation used for road aggregate, while the lower lift is essentially a good quality dolostone used for concrete and asphalt stone. A rehabilitation program at the southwest corner of the quarry was completed during the summer of 1986; a 3 ha site was developed as a public park and recreation facility and donated to the town of Hagersville.

Spring run-off is the main source of quarry water, and is removed by three 6 in. Flygt electric submersible pumps. Blast holes 76 mm in diameter are drilled by a JOY VCR-260 air track on a 2.75 m x 3.05 m pattern. Holes are column loaded with AN/FO, toe primed with watergel slurry cartridges and initiated with electric caps. Blasted stone is loaded by a single Cat 988 7 yd. loader into haulage trucks (three Euclids, two 20 ton and a single 35 ton, one of which serves as a spare). The average haulage distances from the face to the crusher are 175 m and 325 m for the upper and lower benches respectively.

## PROCESSING

The process flow sheet is shown on Figure NI-5-3. Primary crushing of the blasted stone is by a 36 in. x 48 in. Cedarapids jaw crusher. The crushed material is then carried on a 30 in. conveyor for approximately 600 m to a 150 ft. radial stacker and surge pile. From the surge pile the stone is processed through a series of secondary crushers and vibratory screens. Secondary crushing is performed by 4 1/4 ft., 4 ft. and 3 ft. Symons cone crushers that feed 6 ft. x 16 ft. and 6 ft. x 14 ft. double-deck Dillon screens, as well as 8 ft. x 20 ft. and 5 ft. x 14 ft. triple-deck Tyler screens. The stone products are used for road and concrete aggregate.

The stone products are stockpiled then rehandled for shipping by a Clark 175 front-end loader. At present all shipping is by truck; rail facilities still exist at the site but are not currently used.

## PRODUCTS

Gabion Stone
6 in. Crusher Run
3 in. Crusher Run
2 in. Crusher Run
3/4 in. Crusher Run
2 in. Clear
3/4 in. Clear
3/8 in. Clear
1/4 in. Clear
Screenings
3/4 in. Concrete Stone
Agricultural Lime

## REFERENCES

Best, 1953, p.35-36
Caley, 1941a, pp.44,47,48,51,64
Goudge, 1938, p.233
Hewitt, 1960, p.140-142
Hewitt, 1964a, p.63
Hewitt and Vos, 1972, p.61
Kobluk and Brookfield, 1982, p.24-27

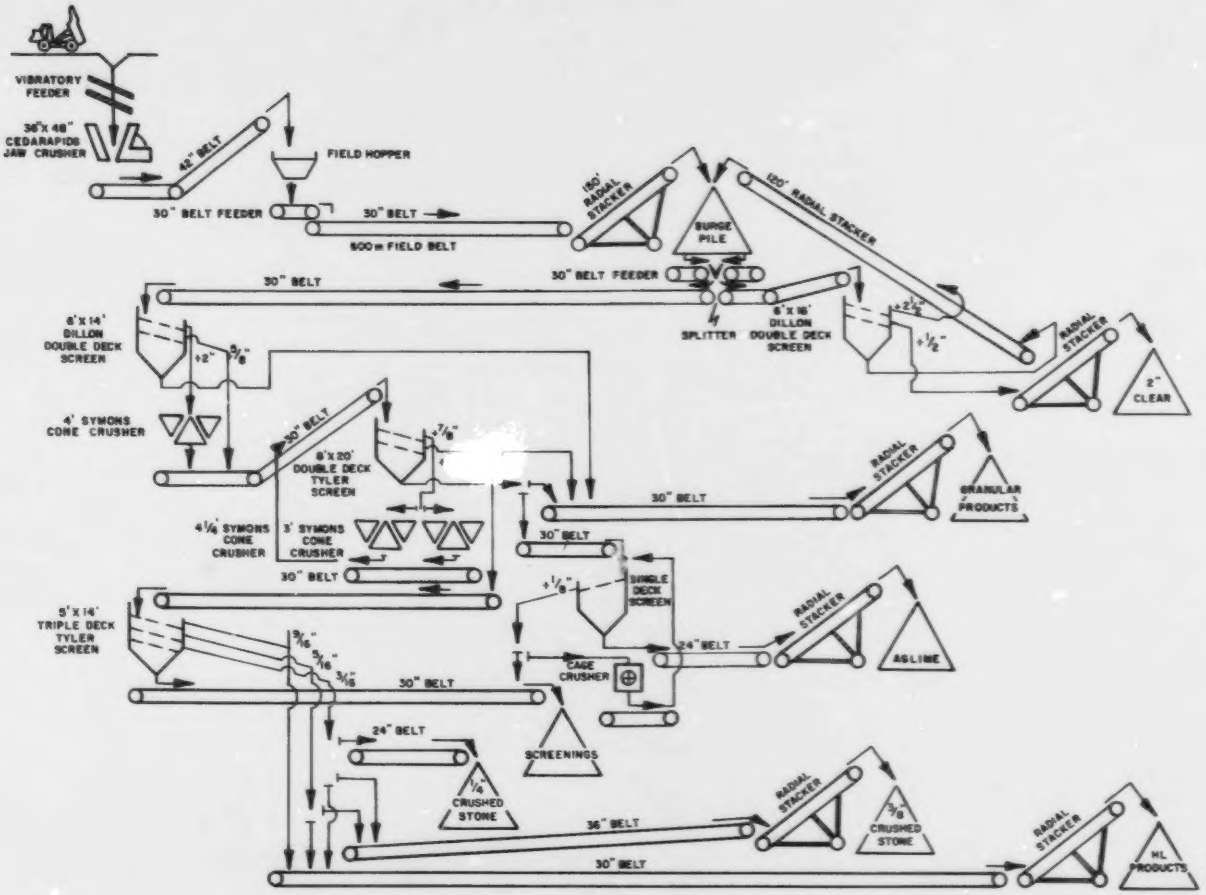

VIBRATORY FEEDER
36" X 48" CEDARAPIDS JAW CRUSHER
42" BELT
FIELD HOPPER
30" BELT FEEDER
30" BELT
600 m FIELD BELT
150' RADIAL STACKER
SURGE PILE
120' RADIAL STACKER
30" BELT FEEDER
30" BELT
SPLITTER
6' X 16' DILLON DOUBLE DECK SCREEN
+2½"
+½"
RADIAL STACKER
2" CLEAR
6' X 14' DILLON DOUBLE DECK SCREEN
+2"
5/8"
4' SYMONS CONE CRUSHER
30" BELT
+7/8"
8' X 20' DOUBLE DECK TYLER SCREEN
30" BELT
RADIAL STACKER
GRANULAR PRODUCTS
4¼' SYMONS CONE CRUSHER
3' SYMONS CONE CRUSHER
30" BELT
30" BELT
+1/8"
SINGLE DECK SCREEN
5' X 14' TRIPLE DECK TYLER SCREEN
9/16"
5/16"
3/16"
30" BELT
CAGE CRUSHER
24" BELT
RADIAL STACKER
AGLIME
24" BELT
SCREENINGS
1/4" CRUSHED STONE
36" BELT
RADIAL STACKER
3/8" CRUSHED STONE
30" BELT
RADIAL STACKER
HL PRODUCTS

Figure NI-5-3. PROCESS FLOW SHEET FOR HAGERSVILLE QUARRY.

**Photo NI-5-2. PROCESSING PLANT FIELD CONVEYOR, SURGE PILE (FOREGROUND) AT HAGERSVILLE QUARRY. SECONDARY CRUSHING AND SCREENING PLANT IN THE BACKGROUND.**

Oliver, 1976, p.144
Uyeno et al., 1982, p.43
ARIP 64, 1985, p.18

### MAPS

Caley, 1941b, GSC Map 619A
Telford and Hamblin, 1980, OGS Map P.2234

## NI-6 NELSON AGGREGATE CO. — WEST ONEIDA QUARRY

### LOCATION AND OWNERSHIP

This small inactive quarry is located 1.5 km south of Clanbrassil in Lot 49, Concession 1N, Town of Haldimand (Oneida Township), Regional Municipality of Haldimand–Norfolk (Figure NI-6-1). This quarry constitutes part of a 208.35 ha licence issued to Nelson Aggregate Co. This licensed area also includes the East Oneida Quarry (NI-7).

### GEOLOGY

The quarry exposes 4.05 m of Upper Silurian and Lower Devonian strata, namely 0.5 m of dolostones of the Bertie Formation, overlain by 3.55 m of the Oriskany Formation, a calcareous sandstone. The sandstone is unique in that it contains large orthoquartzite boulders which occupy the base of the unit as a conglomerate.

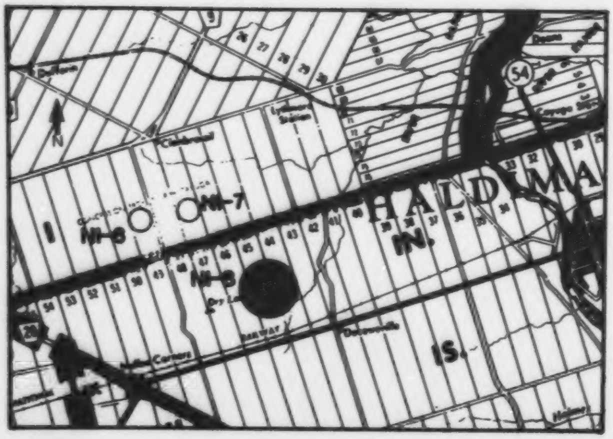


Figure NI-6-1. LOCATION MAP FOR WEST ONEIDA QUARRY.

### Geological Section

*Thickness*

*UNIT 2 Oriskany Formation* *3.55m*

Calcareous sandstone: white to cream, weathers grey-white; medium to coarse grained; thin to medium bedded, contacts are irregular and undulatory; large orthoquartzite boulders occur at the base of the unit, therefore very conglomeratic; sharp lower contact with the Bertie is unconformable.

*UNIT1 Bertie Formation* *0.50m*

Dolostone: mottled grey brown, weathers same; very fine crystalline; thin to medium bedded with irregular contacts; upper contact is jointed and fractured, infilled with sand.

*Total thickness* *4.05m*

### REFERENCES

Best, 1953, p.23, 24–25, 28–30
Telford and Johnson, 1984

### MAPS

Caley, 1941c, GSC Map 584A
Telford and Tarrant, 1975a, ODM Map P.988

## NI-7 NELSON AGGREGATE CO. — EAST ONEIDA QUARRY

### LOCATION AND OWNERSHIP

The quarry is located 1.5 km south of Clanbrassil in Lot 47, Concession 1N, Town of Haldimand (Oneida Township), Regional Municipality of Haldimand–Norfolk (Figure NI-7-1). Extraction from the East Oneida and West Oneida quarries (NI-6) was suspended in 1983.

### GEOLOGY

This intermittently active quarry exposes 18.8 m of Upper Silurian to Lower Devonian strata (Figure NI-7-2). This section includes 12.2 m of the Bertie Formation, 2.2 m of the Oriskany Formation, and 4.4 m of the Bois Blanc Formation. The Bertie Formation consists predominantly of dolostones and dolomitic shales, and its upper contact with the overlying Oriskany Formation is sharp and unconformable. The Oriskany is a pure calcareous sandstone, medium grained with large orthoquartzite boulders at the base. The Bois Blanc Formation is a cherty and sandy limestone.

### Geological Section

*Thickness*

*UNIT 6 Bois Blanc Formation* *4.4m*

Sandy limestone: light brown, weathers grey; fine crystalline; thin to medium bedded; base of unit contains reworked sandstones (medium grained) and chert fragments; grey chert nodules and lenses occur throughout; lower contact is sharp.

*UNIT 5 Oriskany Formation* *2.2m*

Calcareous sandstone: white to cream; weathers same; medium grained; thick to massive bedded, contacts are sharp and undulatory; conglomeratic at base with orthoquartzite boulders; some iron staining; rare corals, brachiopods, and bryozoa; sharp, unconformable contact.

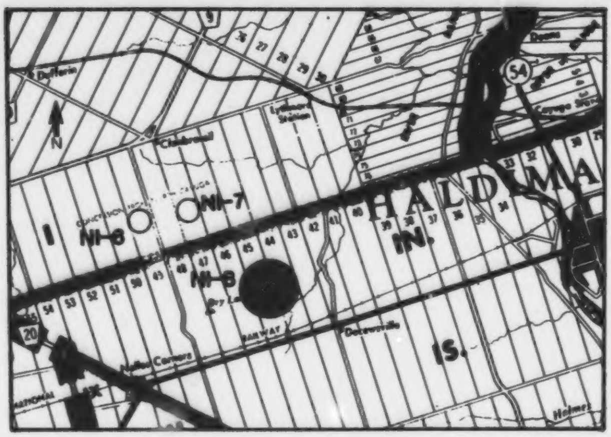


Figure NI-7-1. LOCATION MAP FOR EAST ONEIDA QUARRY.

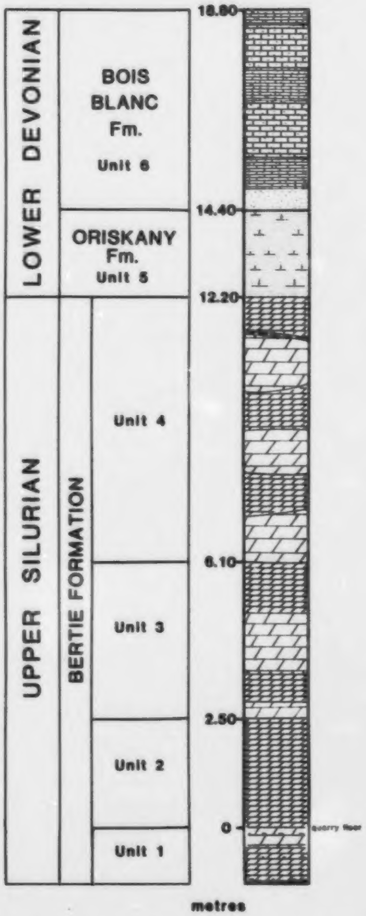


Figure NI-7-2. STRATIGRAPHIC COLUMN FOR EAST ONEIDA QUARRY.

*UNIT 4 Bertie Formation* *6.1m*

Dolostone: buff-brown, weathers same; sub- to very fine-crystalline; thin to medium bedded, contacts are undulatory; top is very jointed and fractured, infilled with quartz sand; some shale seams at top; also some breccia-tion; has a mottled appearance; some beds are contorted; lower contact is gradational.

*UNIT 3 Bertie Formation* *3.6m*

Dolostone: buff grey to brown, weathers same; very fine crystalline; medium to thick bedded; has a mottled appearance; sharp lower contact.

*UNIT 2 Bertie Formation* *2.5m*

Dolomitic shale: grey-brown, weathers blue-grey to brown; thin bedded and fissile; lower contact is covered.

*UNIT 1 Bertie Formation* *quarry floor*

Bituminous dolostone: dark brown, weathers same; fine to medium crystalline; thin to medium bedded; very abundant bituminous partings and with a strong odor; located below quarry floor.

*Total thickness* *18.8m*

### REFERENCES

Caley, 1940, p.83–84
Fahselt et al., 1979
Goudge, 1938, p.234
Uyeno et al., 1982, p.43
Winder and Sanford, 1972, p.66
ARIP 64, 1985, p.10

### MAPS

Caley, 1941c, GSC Map 584A
Telford and Tarrant, 1975a, ODM Map P.988

## NI-8 CAYUGA MATERIALS AND CONSTRUCTION CO. — CAYUGA QUARRY

### LOCATION AND OWNERSHIP

The Cayuga Quarry of Cayuga Materials and Construction Co. is located 5.5 km west of the village of Cayuga on the north side of Highway No. 3, in Lots 44, 45, 46 and 47, Concession 1N, Town of Haldimand (North Cayuga Township), Regional Municipality of Haldimand–Norfolk (Figure NI–8–1). The quarry and processing plant have been in operation since 1957. The quarry licence covers an area of 176.2 ha.

### GEOLOGY

In the Cayuga Quarry, a total of 19.8 m of section is exposed and consists of the Upper Silurian Bertie Formation through tc the Lower Devonian Oriskany and Bois Blanc Formations (Figure NI–8–2). The Bertie Formation exhibits 15.4 m of section with lithologies ranging from dolomitic shales to dolostones to shaly dolostones. Overlying the Bertie Formation is 2.9 m of the Oriskany Formation, a calcareous sandstone, overlain by 1.5 m of the Bois Blanc Formation, a cherty limestone. The Oris-

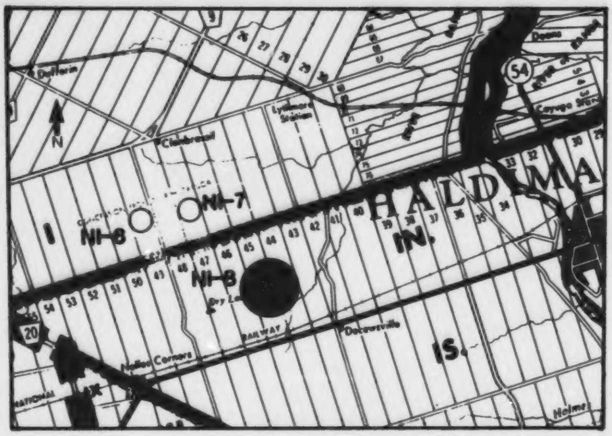


Figure NI-8-1. LOCATION MAP FOR CAYUGA QUARRY.

kany Formation is the prominent feature in this quarry. The formation weathers quickly to sand when the overlying Bois Blanc Formation is removed. Faulting occurs along the west face. Overburden is thin around the quarry.

## Geological Section

| | | *Thickness* |
|---|---|---|
| *UNIT 6* | *Bois Blanc Formation* | *1.5m* |

Cherty limestone: light brown, weathers grey; fine to medium crystalline; thin to medium bedded (less than 10 cm), contacts are sharp, undulatory and irregular; rare shaly partings with glauconitic staining; scattered quartz lenses and clasts (coarse grained); scattered stylolitic and bituminous partings; chert is white to light grey, usually bounded by stylolites; abundant iron staining, pyrite mineralization occurs as clasts and in pores; rare colonial and solitary corals, brachiopods, and abundant bivalves; lower contact is sharp to transitional.

| | | |
|---|---|---|
| *UNIT 5* | *Oriskany Formation* | *2.9m* |

Calcareous sandstone: light cream to white, weathers buff; medium to coarse grained; thick bedded, contacts are sharp and irregular; lower 30 cm is conglomeratic with clasts of calcareous glauconitic shale, dolostones and mudstones, clasts are oval in shape and some possess lamination; abundant hematitic staining and nodules; few scattered brachiopods, becomes more fossil-rich in the upper part; sharp lower contact – a major unconformity.

Unit 6: Bois Blanc Formation

Unit 5: Oriskany Formation

Unit 4: Bertie Formation

Photo NI-8-1. TYPICAL SECTION AT CAYUGA QUARRY.

*UNIT 4 Bertie Formation* *9.3m*

Dolostone: medium to light brown, weathers light to dark brown to buff; sub- to fine-crystalline; medium to thick bedded (0.40 to 1.50 m), contacts are sharp and undulatory; three variations of dolostones interbedded with each other: a light brown, a dark brown, and a mottled dolostone, each occurring in varying proportions; some beds are laminated, rare shale interbeds; pyrite mineralization abundant in lower 1 m and occurs in large pores, calcite occurs in pores and fractures; abundant fossil debris in scattered zones, abundant vertical burrows in some beds; sharp lower contact.

*UNIT 3 Bertie Formation* *3.1m*

Interbedded shaly dolostones and dolomitic shales: grey to brown, weathers blue-grey to brown; fine crystalline; thin to medium bedded (5 to 40 cm), contacts are sharp, planar, and laterally extensive; laminated; fractured and brecciated zones present, infilled with quartz sandstone (coarse grained); chert present; lower contact is sharp, a single clay seam.

*UNIT 2 Bertie Formation* *3.0m*

Dolostone: brown, weathers same; fine to medium crystalline; thin to medium bedded ( 2 to 30 cm), contacts are sharp, irregular and undulatory; calcite present along fracture faces, marcasite in pores; very abundant bituminous partings with a strong petroliferous odor; laminated, stylolitic; at base, deformed beds occur and is very porous; chert nodules present at top of unit; lower contact is sharp.

*UNIT 1 Bertie Formation* *quarry floor*

Interbedded dolomitic shales and shaly dolostones: blue-grey, weathers grey; fine crystalline; thin bedded and platy.

*Total thickness* *19.8m*

## QUARRY OPERATION

Annual production takes place over an average 8-month period. Four blasting faces are exposed conforming to Units 5 and 6; Unit 4; the top 1.8 m of Unit 3; and the less shaly lower part of Unit 3 plus the dolostones of Unit 2. The sandstone and cherty limestone of the top lift is used for armour stone. All drilling is performed by Joy and Sullair airtrack drills, with 76 mm diameter holes on 1.8 m x 1.8 m and 2.1 m x 2.3 m patterns. Holes are loaded with AN/FO and initiated by electric caps. Water seepage in the quarry is not significant, but heavy rainfall can make it necessary to blow the holes clear before the explosives are loaded.

## PROCESSING

Blasted stone is transferred by a Cat 988 loader to 35-ton Euclid trucks or transported directly to one of two portable crushing systems. A jaw and cone crusher system produces 3/4 in. and 1/2 in. crusher run stone, and a single jaw crusher feeds -6 in. material onto a 36 in. conveyor. The crushed stone is conveyed 1000 m to the secondary crushing and screening plant. After processing, the stone is stored in stockpiles or 60-ton bulk bins, the latter also being used to blend specific concrete and asphalt stone products. Stockpile material is reclaimed and loaded into trucks or railway cars by front-end loaders. Both rail and truck scales exist at the plant.

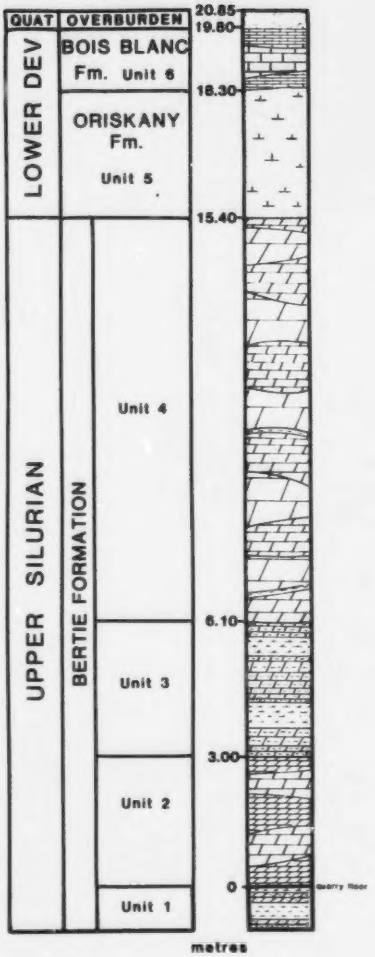


Figure NI-8-2. STRATIGRAPHIC COLUMN FOR CAYUGA QUARRY.

## PRODUCTS

Armour Stone
Quarry Run Stone
36 in. Riprap
24 in. Riprap
18 in. Riprap
12 in. Riprap
8 in. Riprap
Gabion Stone
1 1/2 in. Crusher Run
3/4 in. Crusher Run
1/2 in. Crusher Run

3/8 in. Clear
1/4 in. Clear
Screenings
21A Concrete Stone
HL3 Stone
HL4 Stone
HL5 Stone
"B" Ballast (3/4 in.)
"A" Ballast (1 1/2 in.)
Agricultural Limestone

### REFERENCES

Best, 1953, p.25, 70
Caley, 1940, p.81
Goudge, 1938, p.234–235
Hewitt, 1960, p.138–140
Hewitt and Vos, 1972, p.58–59
Oliver, 1976, p.133
Uyeno et al., 1982, p.43
ARIP 64, 1985, p.18

### MAPS

Caley, 1941c, GSC Map 584A
Telford and Tarrant, 1975a, ODM Map P.988

## NI-9 SWEETS CORNERS QUARRIES

### LOCATION AND OWNERSHIP

Two abandoned quarries are located 5 km northwest of Sweets Corners in Lot 31, Concession 4, Town of Haldimand (South Cayuga Township), Regional Municipality of Haldimand–Norfolk (Figure NI–9–1). The land containing these two quarries has recently been sold to private interests, and the larger water–filled quarry may become a recreational site.

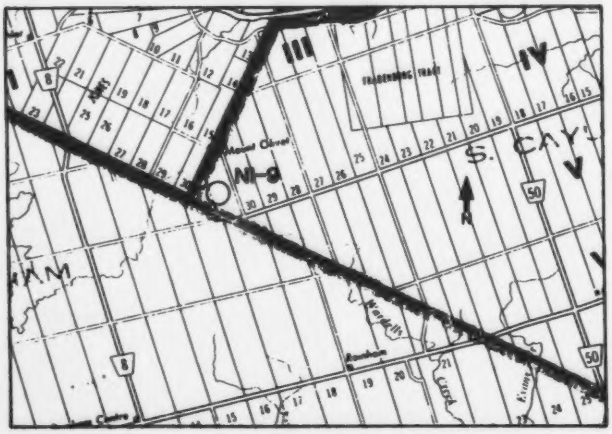


**Figure NI-9-1. LOCATION MAP FOR SWEETS CORNERS QUARRIES.**

### GEOLOGY

The larger quarry exposes 1.3 m of the Edgecliff Member from the Onondaga Formation and is water filled; the other one is smaller and exposes 6.9 m from both the Bois Blanc and the Onondaga Formations. The Bois Blanc Formation is typically a cherty fossiliferous limestone, as is the Edgecliff Member, but displays more biohermal features.

#### Geological Section

| | | *Thickness* |
|---|---|---|
| *UNIT 2* | *Onondaga Formation, Edgecliff Member* | *1.5m* |

Cherty limestone: brown, weathers buff–brown to grey; sub–to fine–crystalline; medium bedded, contacts are undulatory and irregular; some zones are very reefal and biohermal; chert is blue–grey in colour (approximately 15%); rare shale seams; very fossiliferous with bryozoa, solitary corals, colonial corals and crinoids, some have been replaced with blue–grey silica; scattered calcite crystals; lower contact is sharp and disconformable.

| | | |
|---|---|---|
| *UNIT 1* | *Bois Blanc Formation* | *5.4m* |

Cherty limestone: light grey, weathers dark grey; sub– to fine–crystalline; thin to medium bedded, contacts are irregular; top of unit appears to be reworked and contains large solitary corals; some shaly seams; chert is light grey to buff and comprises 50% of the unit; fossiliferous with solitary corals and colonial corals.

*Total thickness* *6.9m*

### REFERENCES

Best, 1953, p.68–69
Oliver, 1976, p.144
ARIP 64, 1985, p.18

### MAPS

Telford and Tarrant, 1975a, ODM Map P.988

## NI-10 DUNNVILLE ROCK PRODUCTS LTD. QUARRY

### LOCATION AND OWNERSHIP

The property of Dunnville Rock Products Ltd. is located 1 km south of the town of Byng, in Pt. Lots 3, 6, 7 and 8, Earl Tract, Town of Dunnville (Dunn Township), Regional Municipality of Haldimand–Norfolk (Figure NI–10–1). The licensed area totals 66.8 ha. The quarry was first opened in the early 1900s and was owned and operated by Haldimand County. In 1942 the property was purchased by P. L. Jackson and became known as Dunnville Rock Products. In 1963 the organization changed and became a private limited company under the present name Dunnville Rock Products Ltd. The company presently has ownership ties with Waterford

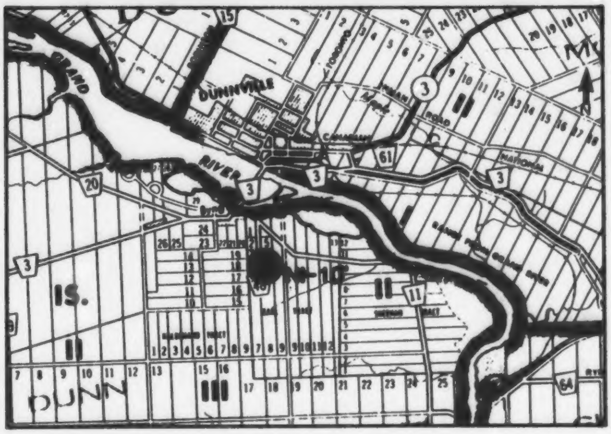


Figure NI-10-1. LOCATION MAP FOR DUNNVILLE ROCK PRODUCTS QUARRY.

Sand and Gravel Ltd. and Waterford Crushing and Screening.

## GEOLOGY

In the Dunnville Rock Products Quarry, a total of 11.7 m is exposed of the Upper Silurian Bertie Formation and the Lower Devonian Bois Blanc Formation (Figure NI–10–2). The Bertie Formation consists of the lower 8.45 m. Contact with the overlying Bois Blanc Formation is sharp and uncomfortable. The base of the Bois Blanc contains the Springvale Sandstone Member (0.95 m), a calcareous sandstone, with the rest of the formation is a cherty limestone with abundant fossil debris (2.3 m). Overburden is consistently about 3 m thick and its removal exposes a smooth rock surface. Folding and faulting are visible on the south and southwest faces at the quarry.

### Geological Section

*Thickness*

*UNIT 5 Bois Blanc Formation 2.30m*

Cherty limestone: cream to green, weathers white to light grey; very fine crystalline; medium bedded with sharp undulatory contacts; blue chert occurs as nodules and lenses, calcite crystals infill pores and fractures; greenish coloured shale partings occur throughout; abundant fossil debris (including brachiopods, rugose, colonial corals, and nautiloids); lower contact is sharp.

*UNIT 4*
*Bois Blanc Formation, Springvale Sandstone Member 0.95m*

Calcareous sandstone: blue-white to grey, weathers buff; fine to medium grained; thin bedded and very irregular; blue-grey chert occurs as nodules and lenses and infills fractures (brick-like features); top of unit contains large nodules of welded orthoquartzites rimmed with a limestone coating; becomes glauconitic towards the top with shaly partings; lower contact is sharp.

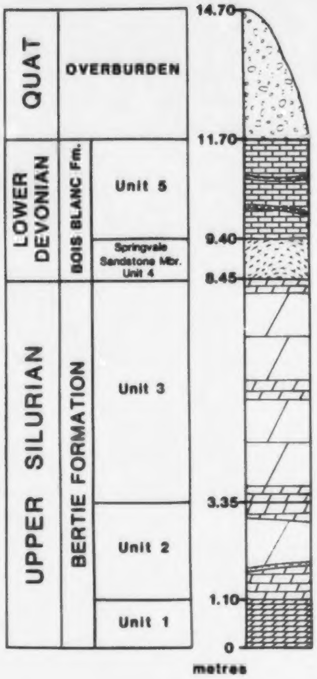


Figure NI-10-2. STRATIGRAPHIC COLUMN FOR DUNNVILLE ROCK PRODUCTS QUARRY.

*UNIT 3 Bertie Formation 5.10m*

Mottled and laminated dolostones: grey to cream, weathers buff; sub- to fine-crystalline; medium to massive bedded, some contacts are sharp, others have bituminous laminae; rip-up clasts present; becomes arenaceous in places and lighter in colour towards the top; sharp lower contact.

*UNIT 2 Bertie Formation 2.25m*

Mottled dolostone: brown-grey, weathers same; sub- to fine-crystalline; medium to massive bedded, contacts are sharp, undulatory and laterally continuous; rare sphalerite mineralization; bituminous residues present on partings; bandings and laminations present towards the base with rare shaly partings; lower contact is covered.

*UNIT 1 Bertie Formation 1.10m*

Dolostone: dark grey, weathers same; very fine crystalline; thin bedded with a shaly appearance (calcilutite); pyrite and calcite mineralization in pores.

*Total thickness 11.70m*

## QUARRY OPERATION

Overburden material is currently hauled approximately 200 m to the eastern quarry limit for rehabilitation of the old face. The quarry is presently advancing to the south on a single lift of 10 m. Dewatering has been a serious problem in the past; pumps were installed in 1967–68 and in 1970 the lower lift of approximately 5 m was opened. Past difficulties in dewatering of the lower lift

Photo NI-10-1.
TYPICAL WORKING FACE AT DUNNVILLE ROCK PRODUCTS QUARRY (LOOKING SOUTHWEST).

will soon be remedied with the completion in the northeast corner of the quarry of a 15 m wide, 5 m high berm, composed of overburden material that will create a pond with an approximate holding capacity of 15,000,000 litres.

Drilling is performed with a Gardner–Denver 3100 airtrack on a 1.5 m x 3.0 m pattern with a hole diameter of 7.6 cm.

Holes are toe loaded and primed with Cilgel 70% stick powder, column loaded with Amex II and initiated with electric delay caps. The blasted stone is loaded by either John Deere 844 (6 yd.), or Massey Ferguson 66 (4.5 yd.) loaders into three Euclid 22–ton trucks.

## PROCESSING

The stationary crushing plant has a capacity of about 300 tonnes/hr. Proposed changes should more than double current production. The blasted stone is hauled 1,000 m from the face to the feed hopper at the stationary plant, where a Jeffrey Vibratory feeder scalps –3 in. material to a conveyor, the +3 in. oversize going to a 20 in. Traylor gyratory crusher. The stone is crushed to –6 in. and joins the scalped undersize on a 40 in. belt conveyor (150 ft.) leading to a 5 ft. x 12 ft. Allis–Chalmers triple–deck screen. The screening products are –6 in. + 1 1/2 in., –1 1/2 in. + 7/8 in. and Granular "A". The –6 in. + 1 1/2 in. material goes to a surge bin and can be passed by a Jeffrey Feeder to a Pulvamatic secondary crusher. The Granular "A" material is stockpiled by a 120 ft. Nordberg stacker. The –1 1/2 in. + 7/8 in. stone goes to a bin as a finished product or can be sent for secondary crushing by a new Hazemag APK unit. The secondary crushing products are conveyed to three 4 ft. x 10 ft. double–deck Tyler screens that produce 1/4 in. washed, 3/8 in. washed, 1/2 in. clear and 3/4 in. clear and 3/4 in. concrete stone (a blend of 3/8, 1/2 and 3/4 in. sizes). The products are stored in 8 bins each with an approximate capacity of 125 tonnes. During the second half of 1986, a large portable H.R.E. crusher was acquired for primary crushing in the pit. The crusher is capable of producing 400 tonnes per hour of –8 in. material which is hauled by 22–ton Euclid trucks to the stationary crushing/screening plant facilities. This new system has increased production to approximately 2,700 tonnes per 8.5 hr. day. Future plans are to incorporate a belt conveyor system (800 m) from the new portable primary crusher to the stationary plant.

## PRODUCTS

Armour Rock
Gabion Stone
Rubble Rock
–6 in. Crusher Run
Granular "A" and "B"
1 1/2 in. Clear
1 1/2 in. Clear
3/4 in. Clear
1/2 in. Clear
3/8 in. Washed
1/4 in. washed
Washed Masonry Sand
Washed Concrete Sand
3/4 in. Concrete Stone
Screenings

## REFERENCES

Best, 1953, p.37, 60
Caley, 1940, p.79, 80–81
Hewitt, 1960, p.136–138
Hewitt and Vos, 1972, p.60–61
ARIP 67, 1984, p.18

## MAPS

Caley, 1941c, GSC Map 584A
Telford and Tarrant, 1975a, ODM Map P.988

## NI-11 HARD ROCK PAVING CO. LTD. — R.E. LAW QUARRY

### LOCATION AND OWNERSHIP

The quarry of Hard Rock Paving Co. Ltd. occupies parts of Lots 3, 4 and 5, Concession 2, Wainfleet Township, Regional Municipality of Niagara, about 3 km west of Port Colborne (Figure NI-11-1). The present working area is located in the northern part of Lot 4, though a mining limit will soon be reached due to the dip of the bedding. Future quarry development will occur in the east half of Lot 5, Concession 2 and progress south towards the existing plant facilities in the east half of Lot 5, Concession 2. The quarry licence covers an area of 135.4 ha.

R.E. Law Crushed Stone began operations in 1937 when Roy E. Law moved his quarry operations from Windmill Point in Fort Erie to a location 3 km west of Port Colborne on Highway 3. Later that year the company was incorporated as R. E. Law Crushed Stone Ltd. In 1978 Hard Rock Paving Co. Ltd. purchased R. E. Law Crushed Stone Ltd.

### GEOLOGY

A total of 17.93 m is exposed through the Upper Silurian Bertie Formation into the Lower Devonian Bois Blanc Formation (Figure NI-11-2). There are 12.58 m of the Bertie Formation, represented by the following members: Falkirk, Scajaquanda, Williamsville and Akron, overlain by 5.35 m of the Bois Blanc Formation with the basal 0.55 cm representing the Springvale Sandstone Member. The dominant lithology for the Bertie Formation is a dolostone which can range from shaly to calcareous. The Bois Blanc Formation is a fine-crystalline, cherty, fossiliferous limestone. The contact between the two formations is sharp and represents a major unconformity. Due to the regional southwest dip the Bois Blanc Formation has its thickest exposure in the southwest corner of the quarry, thinning to the north and east. Overburden consists of 0.3 to 1 m of clay.

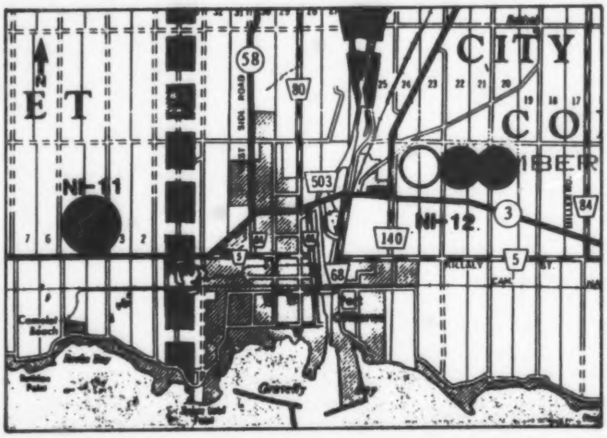

N
ET
CITY
CO
NI-11
NI-12
58
80
503
140
3
84
5
68

Figure NI-11-1. LOCATION MAP FOR R.E. LAW QUARRY.

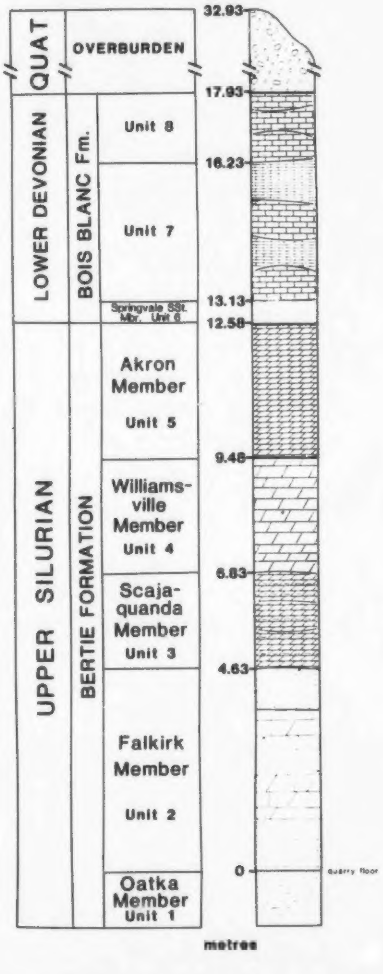

QUAT
OVERBURDEN
LOWER DEVONIAN
BOIS BLANC Fm.
Unit 8
Unit 7
Springvale SSt. Mbr. Unit 6
UPPER SILURIAN
BERTIE FORMATION
Akron Member
Unit 5
Williams-ville Member
Unit 4
Scaja-quanda Member
Unit 3
Falkirk Member
Unit 2
Oatka Member
Unit 1
32.93
17.93
16.23
13.13
12.58
9.48
6.83
4.63
0
quarry floor
metres

Figure NI-11-2. STRATIGRAPHIC COLUMN FOR R.E. LAW QUARRY.

Photo NI-11-1. TYPICAL SECTION OF BOIS BLANC FORMATION OVERLYING THE BERTIE FORMATION AT R.E. LAW QUARRY.

Photo NI-11-2. GARDNER-DENVER AIRTRACK DRILL ON 2ND LIFT OF R.E. LAW QUARRY (LOOKING SOUTH).

## Geological Section

*Thickness*

*UNIT 8 Bois Blanc Formation* *1.70m*

Cherty limestone: buff-brown, weathers buff; fine crystalline; medium bedded with sharp, undulatory contacts; shaly zones present; chert occurs as nodules and irregular, lenticular beds; abundant fossils include rugose and colonial corals; lower contact is sharp.

*UNIT 7 Bois Blanc Formation* *3.10m*

Cherty limestone: buff-cream, weathers buff; fine crystalline; thin to medium bedded (3 to 7 cm), contacts are sharp and undulatory; unit becomes dark grey and coarser crystalline toward the upper part; scattered pyrite and calcite mineralization occurs in small vugs and pores; abundant fossils include bryozoa, brachiopods, nautiloids, rugose corals and rare crinoids; lower contact is irregular with some parts transitional and some sharp.

*UNIT 6*
*Bois Blanc Formation, Springvale Sandstone Member* *0.55m*

Sandstone: green, buff to grey, weathers same; fine to medium grained; thin to medium bedded, contacts are very irregular and mottled; glauconitic with cherty and dolomitic zones; chert occurs as nodules and lenses (green to cream to black in colour); quartz grains are well rounded and clean; some zones of the unit are dolomitic and slightly calcareous; this unit is very irregular and in places fills in cracks and joints in the underlying unit; lower contact is sharp.

*UNIT 5 Bertie Formation, Akron Member* *3.10m*

Dolostone: light grey, weathers brown; sub- to fine-crystalline; thin bedded (1 to 4 cm), contacts are poorly defined and irregular; slightly mottled with a conchoidal fracture; rare shaly laminations and bituminous partings; lower contact is transitional.

*UNIT 4 Bertie Formation, Williamsville Member* *2.65m*

Dolostone: light grey, weathers buff; sub- to fine-crystalline; medium bedded (up to 40 cm), contacts are sharp; sucrosic appearance; fine parallel laminations occur within some of the sandier zones and display scouring features; west face contains fractures infilled with glauconitic sandstone and chert; calcite mineralization present along vertical fracture faces; lower contact is sharp and undulatory.

*UNIT 3 Bertie Formation, Scajaquanda Member* *2.20m*

Dolostone: dark grey, weathers blue-grey; sub- to fine-crystalline; thin bedded (2 to 15 cm), contacts are sharp and undulatory; shaly partings are abundant; sedimentary features are present including slumping and compaction; bituminous odor; unit thickness is variable throughout the quarry; rare chert nodules; lower contact is sharp.

*UNIT 2 Bertie Formation, Falkirk Member* *4.63m*

Calcareous dolostone: brown, weathers same; fine crystalline; thin to medium bedded ( 3 to 20 cm), contacts are welded, some have bituminous partings; abundant dark laminae and banding; partly stylolitic; porous; pyrite mineralization occurs along laminations; iron staining present in vugs, rare calcite and dolomite crystals in small pores and vugs; rare bryozoa; upper 20 cm of the unit is brecciated and contorted; lower contact is covered.

*UNIT 1 Bertie Formation, Oatka Member* *quarry floor*

Dolomitic shale: dark grey, weathers blue-grey; very fissile and platy, occurs at quarry floor.

*Total thickness* *17.93m*

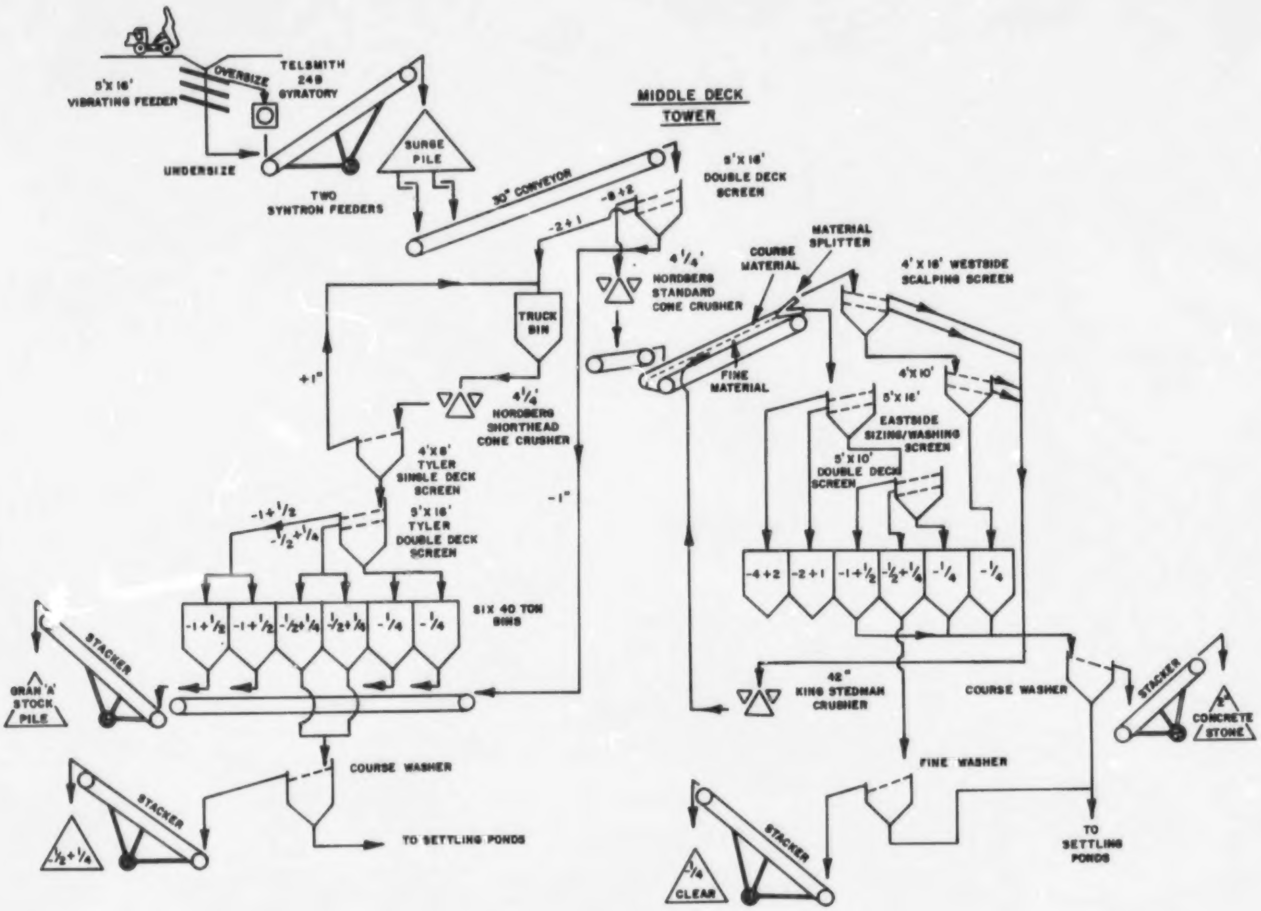

5'X 16'
VIBRATING FEEDER
OVERSIZE
TELSMITH
24B
GYRATORY
UNDERSIZE
TWO
SYNTRON FEEDERS
SURGE
PILE
30" CONVEYOR
MIDDLE DECK
TOWER
5'X 16'
DOUBLE DECK
SCREEN
-8+2
-2+1
4 1/4'
NORDBERG
STANDARD
CONE CRUSHER
COURSE
MATERIAL
MATERIAL
SPLITTER
4' X 16' WESTSIDE
SCALPING SCREEN
TRUCK
BIN
FINE
MATERIAL
4'X 10'
5'X 16'
EASTSIDE
SIZING/WASHING
SCREEN
5'X 10'
DOUBLE DECK
SCREEN
+1"
4 1/4'
NORDBERG
SHORTHEAD
CONE CRUSHER
4'X 8'
TYLER
SINGLE DECK
SCREEN
-1"
-1+1/2
-1/2+1/4
5'X 16'
TYLER
DOUBLE DECK
SCREEN
-1+1/2
-1+1/2
-1/2+1/4
-1/2+1/4
-1/4
-1/4
SIX 40 TON
BINS
-4+2
-2+1
-1+1/2
-1/2+1/4
-1/4
-1/4
STACKER
GRAN 'A'
STOCK
PILE
42"
KING STEDMAN
CRUSHER
COURSE WASHER
STACKER
2"
CONCRETE
STONE
COURSE WASHER
STACKER
-1/2+1/4
TO SETTLING PONDS
FINE WASHER
STACKER
-1/4
CLEAR
TO
SETTLING
PONDS

Figure NI-11-3. PROCESS FLOW SHEET FOR R.E. LAW QUARRY.

## Quarry Operation

The thin clay overburden covers 2.0 to 2.5 m of fractured cherty cap rock that constitutes the top lift of the quarry. The cap rock used to be removed by drilling and blasting but is now broken and removed with a bulldozer and ripper and used locally for fill and to backfill depleted quarry faces.

The second lift consists of Bertie Formation, Akron Member dolostone which thickens southwestwards from 5 to 7 m. This lift is drilled on a 2.4 x 3.7 m pattern with 10 cm diameter holes. The third (bottom) lift extracts the Bertie Formation dolostones and varies in height from 7 to 12 m. Drilling is on a 2.4 x 2.4 m pattern with 10 cm diameter holes, carried out with a Gardner–Denver HDOF carrier, PRH80 hammer and a 1600 cfm Ingersoll–Rand compressor.

Wet holes are blown out with compressed air; all holes are toe loaded with 75 mm x 400 mm Powerfrac 75% stick powder and column loaded with AN/FO. The blast holes are primed with 50 mm x 400 mm Cilgel 70% and initiated by electric delay caps, and 1,500 to 2,000 tonnes of stone are blasted each day in approximately 30 holes.

## Processing

The process flow sheet is shown on Figure NI–11–3. The Law quarry has an average nine–month operating year. The crushing facilities have a rated capacity of 2,600 tonnes per day. Blasted stone is loaded by a 7–yd. Terex 7271B onto two R25 Euclid trucks 1300 m to the primary feed hopper. A 5 ft. x 16 ft. Simplicity vibratory feeder is used to scalp the fine feed material, with the oversize going to the primary Telsmith 24B gyratory crusher. The crushed stone then joins the scalped feeder

Photo NI-11-3. PROCESSING PLANT SHOWING PRIMARY CRUSHER, SURGE PILE AND SCREENING TOWERS AT R.E. LAW QUARRY.

fines and is stockpiled as a −8 in. surge pile. The surge pile is recovered by two Syntron feeders to a 30 in. tunnel conveyor and transferred to the middle screening tower. The stone is separated by a 5 ft. x 16 ft. double–deck Tyler screen which produces a −8 in. + 2 in. material for secondary crushing (Nordberg 4.5 ft. standard cone), −2 in. + 1 in. for secondary crushing (Nordberg 4.5 ft. shorthead cone) and −1 in. for the Granular "A" stockpile. Crushed stone leaving the Nordberg shorthead is screened by 4 ft. x 8 ft. single–deck Tyler screen which removes +1 in. oversize for recrushing and a 5 ft. x 16 ft. double–deck Tyler screen which produces −1/4 in., −1/2 in. + 1/4 in. and −1 in. + 1/2 in. stone. These three products are each stored in two 40–ton bins and can be loaded onto trucks for stockpiling, sent to the washing facilities, or added to the −1 in. material (from the middle screening tower), and conveyed to the Granular "A" stockpile. The Nordberg standard cone crusher produces −4 in. material that is conveyed to the top screening tower. From the conveyor belt the −4 in. stone can be sent to either the eastside sizing and washing screens for direct product sizing, or to the westside scalping screens (double–deck Tyler 4 ft. x 16 ft. and 4 ft. x 10 ft.), and recrushing in a King Stedman 42 in. crusher. Recrushed material is returned to one side of the conveyor belt and sent through the 5 ft. x 16 ft. and 5 ft. x 10 ft. double–deck screens of the eastside sizing and washing circuit. Minus 4 in. + 2 in., −2 in. + 1 in., −1 in. + 1/2 in., −1/2 in. + 1/4 in. material and −1/4 in. fines are produced and stored in 50–ton bins. Products in the bins may be removed and sent for washing at the fine or coarse washer.

A 250 tons per hour asphalt plant is also located at the quarry.

### PRODUCTS

Armour Stone
Riprap
Quarry Rubble
−4 in. Crusher Run
Granular "A" and "B"
2 in. Clear
3/4 in. Clear
3/8 in. Clear
21A Concrete Stone
HL6 and HL3

### REFERENCES

Best, 1953, p.53–55
Caley, 1940, p.88, 102
Hewitt, 1960, p.134–136
Hewitt, 1964a, p.63
Hewitt and Vos, 1972, p.61–62
Kobluk and Brookfield, 1982, p.27–29
Oliver, 1976, p.143–144
Uyeno et al., 1982, p.43
ARIP 115, 1985, p.17

### MAPS

Caley, 1941c, GSC Map 584A
Telford and Tarrant, 1975b, ODM Map P.989

## NI–12 PORT COLBORNE QUARRIES LTD. – PORT COLBORNE QUARRY

### LOCATION AND OWNERSHIP

This operating quarry is located 2 km northeast of Port Colborne on Chippewa Road in Lots 19 to 22, Con. 2, City of Port Colborne (Humberstone Township), Regional Municipality of Niagara (Figure NI–12–1). Two quarries are located here; one depleted and the other extending eastward. The licensed area of the quarry is 142.1 ha.

### GEOLOGY

A total of 15.27 m of section is exposed with 12.23 m of the Upper Silurian Bertie Formation and 3.04 m of the Lower Devonian Bois Blanc Formation present (Figure NI–12–2). The Bertie Formation here consists of the

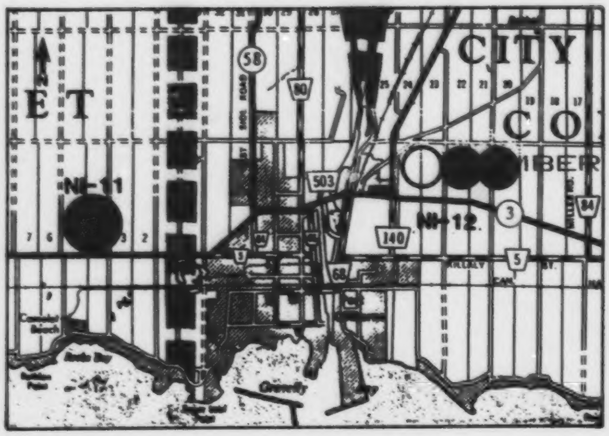


Figure NI-12-1. LOCATION MAP FOR PORT COLBORNE QUARRY.

Akron, Williamsville, Scajaquanda, Falkirk and Oatka Members with lithologies ranging from dolomitic shales to shaly and calcareous dolostones to dolostones. The Bois Blanc Formation is a cherty limestone with some shaly zones. The quarry operates in three lifts and has 1 to 3 m of overburden.

## Geological Section

| | | *Thickness* |
|---|---|---|
| *UNIT 6* | *Bois Blanc Formation* | *3.04m* |

Cherty limestone: light grey-cream, weathers mottled; fine crystalline; thin to medium bedded, contacts are sharp, undulatory, some have shaly partings; white to grey chert, occurs as nodules and lenticular beds; very fossil rich with abundant bryozoa, rugose, crinoids, brachiopods and fragments, many are replaced by silica; the base of this unit is a shaly sandstone bed (probably the Springvale Sandstone Member); lower contact is sharp.

*UNIT 5 Bertie Formation, Akron Member* *2.57m*

Dolostone: grey-brown, weathers buff; fine crystalline; medium to thick bedded, contacts are sharp and undulatory; calcite and chert mineralization occurs in fractures, pyrite occurs along bedding planes; sucrosic and very mottled; glauconitic sand infills voids and cracks along the upper contact; lower contact is transitional.

*UNIT 4 Bertie Formation, Williamsville Member* *2.84m*

Calcareous dolostone: light to medium grey, weathers buff; fine crystalline; very thin to medium bedded, contacts are sharp, but irregular and undulatory, mottled appearance; chert occurs in scattered layers; lower contact is sharp.

*UNIT 3 Bertie Formation, Scajaquanda Member* *1.91m*

Calcareous dolostone: grey-green, weathers blue-grey to green; fine crystalline; thin bedded with laminations, contacts are sharp and irregular; some sandy layers occur with minor sedimentary structures such as slump features and draping; rare pyrite mineralization occurs along bedding planes; fossil debris is rare; lower contact is sharp.

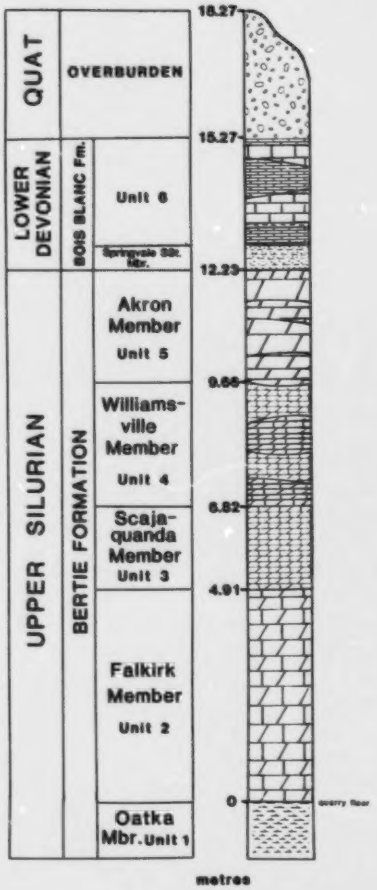


Figure NI-12-2. STRATIGRAPHIC COLUMN FOR PORT COLBORNE QUARRY.

*UNIT 2 Bertie Formation, Falkirk Member* *4.91m*

Calcareous dolostone: dark brown, weathers same; medium crystalline; medium bedded (3 to 40 cm), contacts are welded and some are bituminous; laminations are present; sucrosic and porous; stylolitic; shaly beds present; calcite occurs in fractures, gypsum and selenite crystals in vugs; lower contact is sharp.

*UNIT 1 Bertie Formation, Oatka Member* *quarry floor*

Dolomitic shale: dark grey, weathers green-grey; shaly; very thin bedded, slaty; some sulphide mineralization present.

*Total thickness* *15.27m*

## QUARRY OPERATION

The quarry has a production capacity of 7,200–11,000 tonnes/day based on an 8-hour day. Production could be increased to 15,000 tonnes per 8-hour shift with little difficulty. The quarry operates only during the shipping season from mid-March to the end of December. A third property of approximately 70 ha lies to the east of

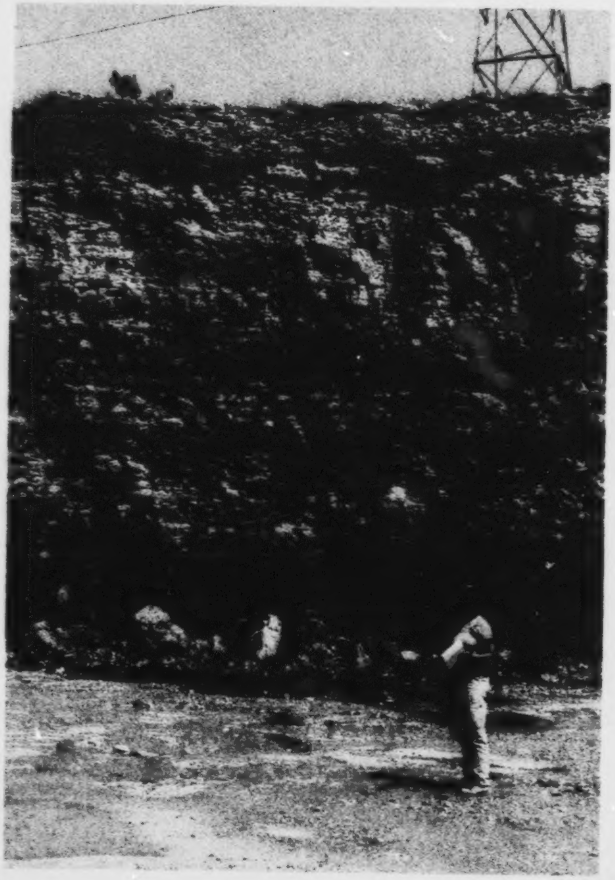


Photo NI-12-1. TYPICAL SECTION AT PORT COLBORNE QUARRY.

the existing quarry. This area will be accessed by means of a tunnel under a township road. Nearby urban growth is placing constraints on the operation of the quarry in terms of blasting and haulage activities.

Overburden is removed by a Caterpillar D-9 bulldozer and piled into berms for screening and noise reduction, or reserved for pit rehabilitation. Stripping is complete on the south side of the quarry and a berm is being constructed.

Drilling is conducted by quarry staff using rotary drills, either a Joy Mustang 1700 series or a Gardner-Denver 2000 series drill is used. Both drill 10 cm holes on a 3 m x 3 m pattern. Drilling is to full bench height. AN/FO premix is used for blasting, either Powerfrac 75 or Powermix 300, with a 2 m collar. Blasting is conducted sequentially. There is a minimum of two, and a maximum of four, blasts per day, in the morning and afternoon. The rock shatters freely and no secondary breaking is required.

The lower member of Unit 6, which is comprised of a shaly sandstone 60 cm to 120 cm thick is ripped using a D-9 Caterpillar bulldozer. The material may be used for berm construction, or stored for pit rehabilitation.

## PROCESSING

The process flow sheet is shown on Figure NI-12-3. Blasted material is loaded into trucks using 3 Clark 475 and 2 Cat 992 17 yd. front end loaders. Rock is loaded into two 85-ton Euclid and 3 50-ton Euclid trucks and transported approximately 300 m to 450 m to the primary crusher.

The primary crusher is located adjacent to the old quarry. It is a Cedarapids dual impact model 5460 unit which reduces the rock to 8 in. to 6 in. After initial screening the stone passes to a Hewitt-Robins 48 in. single impact crusher where material is reduced to 4 in. to dust size in closed circuit. Secondary crushed material is stored in a 60,000 tonne surge pile on the floor of the old quarry.

Material is reclaimed from the surge pile by means of underground conveyor and sent to a screening plant. Plus 2 in. material is conveyed to storage on the floor of the old quarry. The balance of the material is passed to either a 4.25 in. or 5.5 in. Cedarapids cone crusher to produce +3/8 in, -1 in. material. This material is washed in a tub washer and dried in a drum dryer and is the main export product. After washing and drying the stone is conveyed to either overhead storage bins for truck loading, or moved by conveyor to storage piles.

Wash water is passed to settling ponds in the old quarry for clarification. Make-up water is provided by pit runoff. Both the working pit and the old quarry are dry. Pumping is provided by an 8 in. Gorman-Rupp centrifugal pump.

Material for export is hauled by independent contractor to storage and dock facilities at Wharf 12 on the east side of the Welland Canal at Port Colborne. The total storage and dock area is 13 acres. Stone is dumped and then piled by a D-9 Cat bulldozer. Shiploading is by means of a gravity fed 48 in. underground conveyor feeding a 2,000-2,200 tonne/hr. luffing loader. The total length of the dock is 1,800 ft. The main product sizes exported are 3/8 in., 3/4 in., 1 in., 2 in., and 4 in.

## PRODUCTS

4 in. Clear
2 in. Clear
1 in. Clear
3/4 in. Clear
5/8 in. Clear
3/8 in. Clear

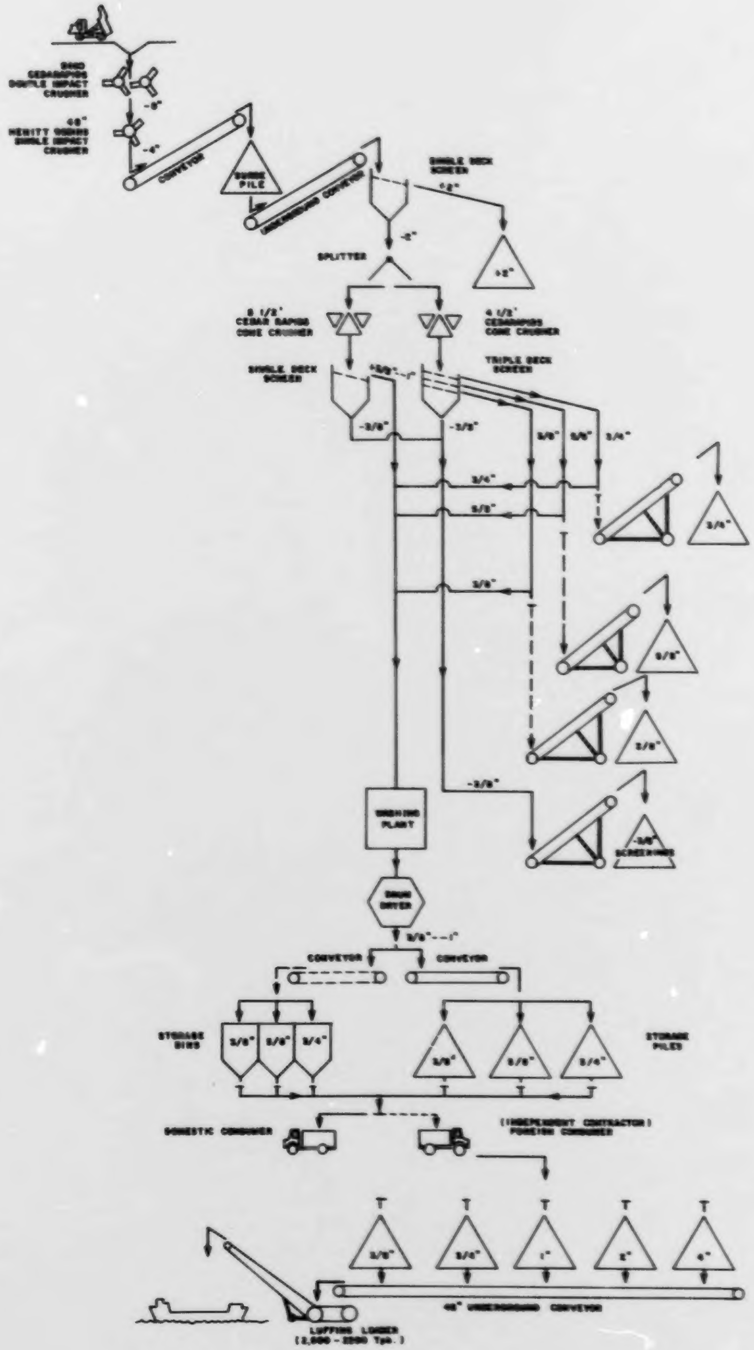

CRUSHER
-8"
CRUSHER
-4"
CONVEYOR
SURGE PILE
UNDERGROUND CONVEYOR
SINGLE DECK SCREEN
+2"
-2"
SPLITTER
+2"
CONE CRUSHER
CONE CRUSHER
SINGLE DECK SCREEN
TRIPLE DECK SCREEN
-3/8"
-3/8"
3/8"
5/8"
3/4"
3/4"
5/8"
3/8"
3/4"
5/8"
3/8"
-3/8"
-3/8" SCREENINGS
WASHING PLANT
SAND DRYER
CONVEYOR
CONVEYOR
STORAGE BINS
3/8"
5/8"
3/4"
STORAGE PILES
3/8"
5/8"
3/4"
DOMESTIC CONSUMER
(INDEPENDENT CONTRACTOR)
FOREIGN CONSUMER
3/8"
3/4"
1"
2"
6"
48" UNDERGROUND CONVEYOR
LUFFING LOADER
(2,000 - 2500 Tph.)

Figure NI-12-3. PROCESS FLOW SHEET FOR PORT COLBORNE QUARRY.

### REFERENCES

Hewitt, 1960, p. 130–132
Hewitt, 1964a, p. 61–62
Hewitt and Vos, 1972, p. 62
ARIP 117, 1985, p. 22

### MAPS

Owen, 1972, GSC Map 8–1971
Telford and Tarrant, 1975b, ODM Map P.989

## NI–13 BERTIE BAY QUARRY

### LOCATION AND OWNERSHIP

Two abandoned quarries are located 3 km west of Bertie Bay on Lake Erie in Lot 12, Concession 2, Town of Fort Erie (Bertie Township), Regional Municipality of Niagara (Figure NI–13–1).

### GEOLOGY

The smaller quarry of the two exposes 4.2 m of the Clarence Member from the Onondaga Formation, a fine- to medium-crystalline and sucrosic cherty limestone that displays silicified crinoids and rugose corals.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 1 Onondaga Formation, Clarence Member* | *4.20m* |
| Cherty limestone: brown–grey, weathers light brown; fine to medium crystalline; fine to medium bedded, contacts are undulatory; sucrosic; abundant silicified crinoids and rugose corals are present. | |
| *Total thickness* | *4.20m* |

### REFERENCES

Best, 1953, p.48–49
Goudge, 1938, p.286
Oliver, 1976, p.143–144
ARIP 117, 1985, p.23

### MAPS

Caley, 1941c, GSC Map 584A
Telford and Tarrant, 1975b, ODM Map P.989

## NI–14 RIDGEMOUNT QUARRIES LTD. – PIT 1

### LOCATION AND OWNERSHIP

This large quarry is located 2.5 m south of Ridgemount and just south of the large operating quarry (NI–15), in Lots 3 and 4, Concession 8 NR, Town of Fort Erie (Bertie Township), Regional Municipality of Niagara (Figure NI–14–1). The quarry licence covers an area of 82.19 ha. It is owned by Walker Industries Holdings Limited.

### GEOLOGY

The quarry exposes 10.69 m of section ranging from the Upper Silurian Bertie Formation through to the Middle Devonian Onondaga Formation, Edgecliff Member (Figure NI–14–2). The Bertie Formation is represented by 1.35 m of the Akron Member, a subcrystalline to fine-crystalline dolostone with some green to cream–coloured chert. Towards the top, abundant glauconite clasts occur which are surrounded by a coarse quartz sand. The Bertie is sharply overlain by the Bois Blanc Formation on an erosional contact. The Bois Blanc Formation is a cherty, dolomitic limestone with shaly partings. In places it can be very fossiliferous with coquinas of brachiopods and coral debris. Chert occurs as thin beds or nodules.

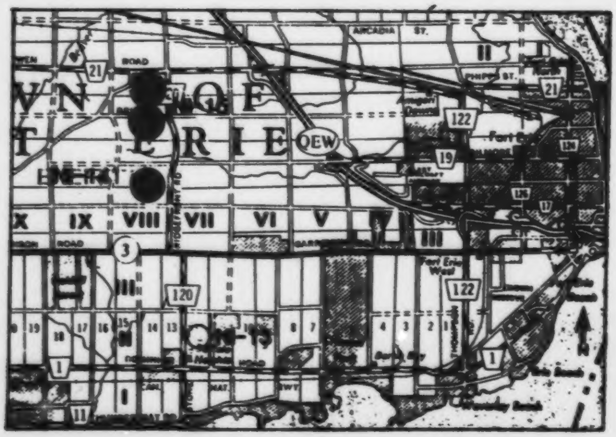


**Figure NI-13-1. LOCATION MAP FOR BERTIE BAY QUARRY.**

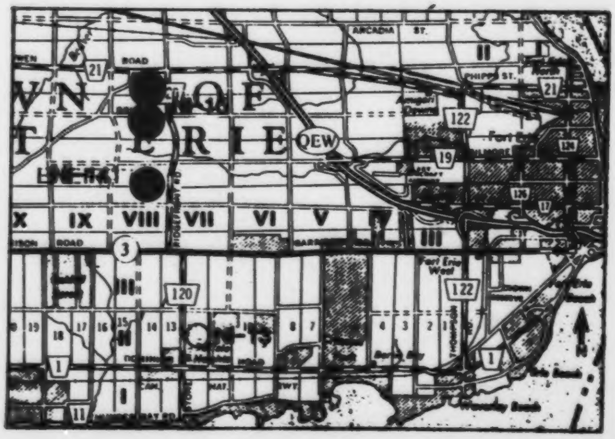


**Figure NI-14-1. LOCATION MAP FOR PIT 1 OF RIDGEMOUNT QUARRIES LTD.**

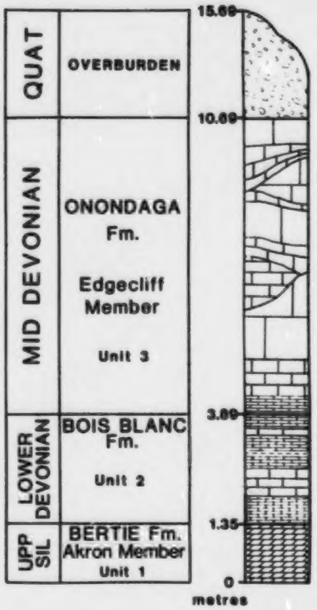

QUAT
OVERBURDEN
MID DEVONIAN
ONONDAGA Fm.
Edgecliff Member
Unit 3
LOWER DEVONIAN
BOIS BLANC Fm.
Unit 2
UPP SIL
BERTIE Fm.
Akron Member
Unit 1
15.69
10.69
3.89
1.35
0
metres

Figure NI-14-2. STRATIGRAPHIC COLUMN FOR PIT 1 OF RIDGEMOUNT QUARRIES LTD.

The Bois Blanc Formation is disconformably overlain by 6.8 m of the Edgecliff Member of the Onondaga Formation. This consists mainly of biohermal and reefal limestones. The biohermal limestones commonly surround or overlie the reefal limestones. The Bois Blanc is typically medium bedded, very fossiliferous and bioclastic, with abundant black chert nodules while the Onondaga is massive, light grey, porous, coarse crystalline, and consists mainly of colonial rugose corals. Currently this quarry is undergoing rehabilitation.

## Geological Section

| | | *Thickness* |
|---|---|---|
| *UNIT 3* | *Onondaga Formation, Edgecliff Member* | *6.8m* |

Reefal and biohermal limestones: cream to brown, weathers buff-grey; fine to medium crystalline, reefy zones can be coarse crystalline; medium to massive bedded, contacts between reefal and biostromal zones are sharp and usually shaly; irregular-shaped black chert nodules occur; very fossiliferous with solitary rugose corals, colonial corals, crinoids, brachiopods, and bryozoans; porous; lower contact is sharp with a 15 cm thick calcarenite (fine to medium grained, brown to green-grey, thin bedded).

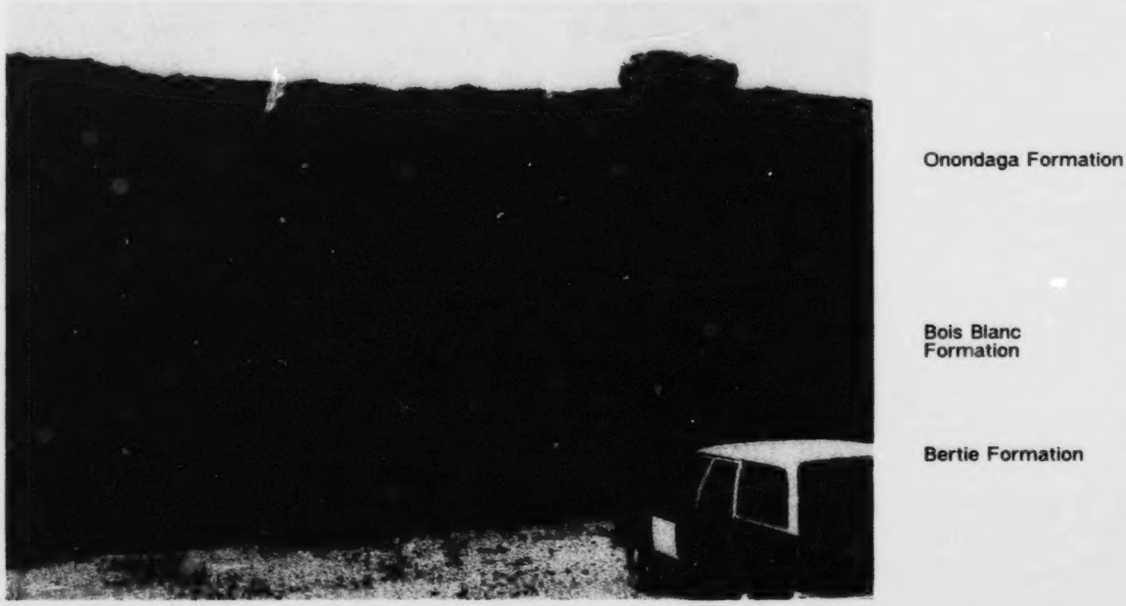

Onondaga Formation
Bois Blanc Formation
Bertie Formation

Photo NI-14-1. TYPICAL QUARRY SECTION AT PIT 1 OF RIDGEMOUNT QUARRIES LTD.

*UNIT 2 Bois Blanc Formation* *2.54m*

Cherty dolomitic limestone: light grey to cream, weathers brown to buff-grey; fine crystalline; thin to medium bedded, contacts are not distinct, contorted, and may be shaly and bituminous; blue-grey to black chert occurs as nodules or lenses; scattered shaly partings occur with some brachiopods; abundant fossils occur in the limestones and include bryozoa, solitary corals and brachiopods; rare dolomite crystals and iron staining are present; the base may possess sandy lenses; lower contact is sharp.

*UNIT 1 Bertie Formation, Akron Member* *1.35m*

Dolostone: cream to light grey, weathers grey to light brown; sub- to fine-crystalline; thin bedded (less than 8 cm), appears laminated in places, contacts are not distinct and some are glauconitic; very mottled appearance; some scattered green chert lenses; abundant pelletoid-like material infilled with calcite, some fossil debris; abundant glauconite sand clasts occur towards the top, and in some places some minor brecciation has taken place.

*Total thickness* *10.69m*

### REFERENCES

Best, 1953, p.49–51
Cassa and Kissling, 1982, p.87–91
Goudge, 1938, p.286
Hewitt, 1960, p.130
Hewitt, 1964a, p.61
Hewitt and Vos, 1972, p.62–63
Oliver, 1976, p.143
Telford and Johnson, 1984, p.18–19
Telford and Johnson, 1985, p.10
Uyeno et al., 1982, p.43
Winder and Sanford, 1972, p.65
ARIP 117, 1985, p.22

### MAPS

Caley, 1941c, GSC Map 584A
Telford and Tarrant, 1975b, ODM Map P.989

## NI-15 RIDGEMOUNT QUARRIES LTD. — PITS 2 AND 3

### LOCATION AND OWNERSHIP

This Ridgemount Quarry location was purchased from Campbell Brothers Quarry Ltd. and has since been amalgamated with Ridgemount Quarries Ltd. as pits 2 and 3. They are owned and operated by Walker Industries Holdings Limited. This operating quarry is located 4 km southeast of Stevensville in Lots 5–8, Concession 8 NR, Town of Fort Erie (Bertie Township), Regional Municipality of Niagara (Figure NI-15-1). The quarry is licensed for 78.14 ha.

The projected Ridgemount #3 quarry, located in Lots 7 and 8, Concession 7 NR, Town of Fort Erie (Bertie Township), is slated for future production by Walker Industries. This property has a quarry licence covering 44.53 ha.

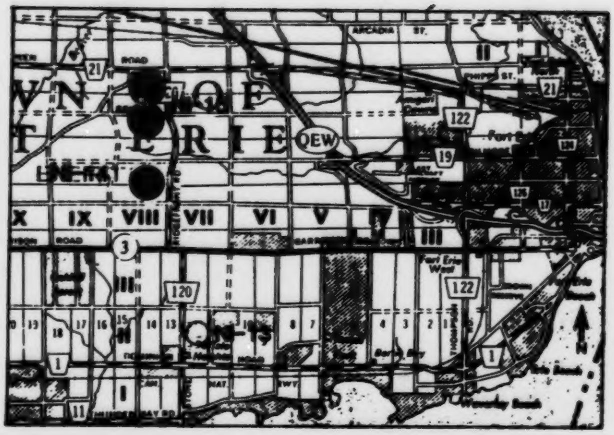


Figure NI-15-1. LOCATION MAP FOR PITS 2 AND 3 OF RIDGEMOUNT QUARRIES LTD.

### GEOLOGY

Pit #2, also known as the Campbell Quarry, exposes 14.25 m of section and includes the Upper Silurian Bertie Formation (11.35 m) and the Lower Devonian Bois Blanc Formation (2.90 m) (Figure NI-15-2). Five members of the Bertie Formation are seen here: the Oatka, Falkirk, Scajaquanda, Williamsville and Akron, with the dominant lithologies consisting of dolostones and shaly dolostones. The Williamsville Member is of interest to fossil collectors for the abundance of eurypterids. The contact of the Bertie and Bois Blanc Formations is sharp and represents a major unconformity. The Bois Blanc Formation is a cherty, fossiliferous limestone with dolomitic zones. Overburden is moderate, from 1.5 to 2 m in thickness.

The quarry operators have plans to extend the quarry southward to join the Ridgemount Quarry Pit 1 (NI-14).

### Geological Section

*Thickness*

*UNIT 6 Bois Blanc Formation* *2.90m*

Cherty limestone: light grey, weathers mottled buff to grey; fine crystalline; thin to medium bedded, contacts are irregular with shaly and bituminous partings; some zones are dolomitic; chert nodules are dark grey to black, some are white and occur as lenses in lower 40 cm; very fossiliferous with silicified brachiopods, bryozoans, crinoids, and large burrows (Chondrites); bedding partly contorted; lower contact is sharp and represents a major unconformity.

*UNIT 5 Bertie Formation, Akron Member* *1.72m*

Dolostone: cream-grey, weathers cream-brown; fine crystalline; thin bedded with sharp, undulatory contacts; has a mottled appearance; lower contact is sharp.

*UNIT 4 Bertie Formation, Williamsville Member 1.56m*

Dolostone: light to medium brown, weathers buff; sub- to fine-crystalline; thin bedded with irregular contacts, bituminous or shaly partings; slightly sucrosic; calcite mineralization in the upper part; rare bryozoans and eurypterids; becomes more mottled upward; lower unit contact is transitional.

*UNIT 3 Bertie Formation, Scajaquanda Member 2.72m*

Interbedded dolostones and shaly dolostones: dark brown to dark grey, weathers blue-grey; sub- to fine-crystalline and fine grained; thin to medium bedded, contacts are sharp with shaly partings; laminated with calcisiltites and calcilutites; calcite mineralization present in fractures, iron staining occurs throughout; rare fossil debris on bedding and laminae planes; lower contact is sharp.

*UNIT 2 Bertie Formation, Falkirk Member 4.75m*

Calcareous dolostone: light to dark brown, weathers medium to dark brown; very fine to fine crystalline; thin to medium bedded with sharp undulatory contacts; bituminous partings are abundant in upper horizon along with stylolitic partings; rare chert present in vugs, marcasite found in small pores; rare algal mounds and brachiopods; abundant pelletal material within laminations; lower contact is covered.

*UNIT 1 Bertie Formation, Oatka Member 0.60m*

Shaly dolostone: dark grey, weathers light blue-grey; sub- to fine-crystalline; medium bedded with abundant laminations and shaly partings along contacts; slaty bedding in part; pyrite nodules occur along laminations and bedding planes.

*Total thickness · 14.25m*

## QUARRY OPERATIONS

The Ridgemount #2 quarry produces aggregate from two lifts of 9.5 m and 5.0 m. Drilling and blasting is carried out by Ridgemount on a 2.74 m x 2.74 m pattern with 7.6 cm diameter holes. Powermex 300 and Amex are used as bulk explosives, initiated with electric caps. Blasted stone is loaded by a Cat. 980 to two 22-ton Terex haulage trucks. A 35-ton Haulpak truck is used as a spare and a 35-ton Mack is used in stockpiling. A VME L190 loader is used to recover material from the stockpile.

## PROCESSING

Crushing and screening are performed with portable equipment: a primary circuit of a Pioneer 3042 jaw crusher and a 5 ft. x 16 ft. triple-deck Tyler screen; a secondary circuit of a Nordberg 4 ft. standard cone crusher and a 6 ft. x 20 ft. Eljay triple-deck screen; and a tertiary crushing circuit of a Telsmith 48S standard cone and a Nordberg 4 1/4 ft. short head crusher that feed the Eljay screen.

## PRODUCTS

Gabion Stone
2 in. Crusher Run
Granular "A"
HL3, HL5, HL6

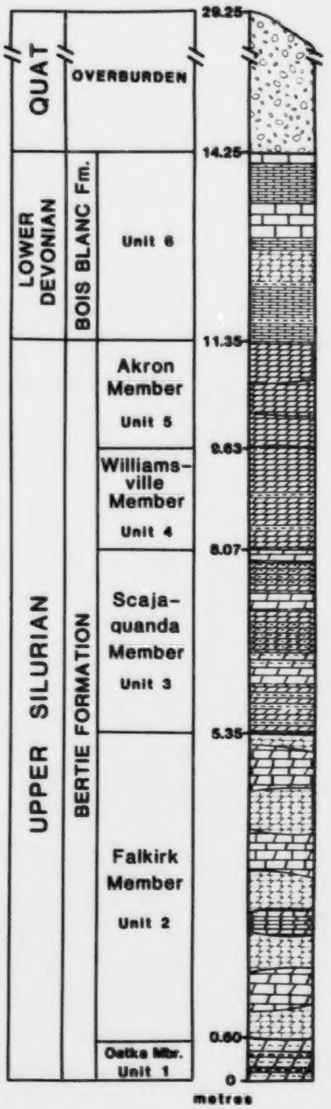


Figure NI-15-2. STRATIGRAPHIC COLUMN FOR PITS 2 AND 3 OF RIDGEMOUNT QUARRIES LTD.

1/2 in., 3/8 in. chips
Screenings

## REFERENCES

Best, 1953, p.51
Caley, 1940, pp.79, 80, 81
Goudge, 1938, p.285
Hewitt, 1960, p.128-130
Hewitt, 1964a, p.60-61
Hewitt and Vos, 1972, p.57-58

Photo NI-15-1. TYPICAL QUARRY SECTION AT PITS 2 AND 3 OF RIDGEMOUNT QUARRIES LTD.

Telford and Johnson, 1984, p.16–17
ARIP 117, 1985, p.22

### MAPS

Caley, 1941c, GSC Map 584A
Telford and Tarrant, 1975b, ODM Map P.989

## NI–16 CLINTON QUARRY LTD.

### LOCATION AND OWNERSHIP

The Clinton Quarry is located 3 km southwest of Vineland, in Lots 5 and 6, Concessions 5 and 6, Town of Lincoln (Clinton Township), Regional Municipality of Niagara (Figure NI–16–1). Owned and operated by Walker Industries Holdings Limited, the Clinton Quarry was opened in 1986 to supplement the supply of stone to the crushing facilities at the Vineland Quarry (NI–2), an adjacent quarry also owned and operated by Walker Industries Holdings Limited. The quarry licence covers an area of 111.3 ha. Products include all sizes of clear, crusher run, granulars, concrete stone, manufactured sand and armour stone. Armour stone is supplied for use along the shores of Lakes Ontario and Erie.

### GEOLOGY

The adjacent Vineland quarry (NI–2) exposes a total of 8.95 m which consists of Middle Silurian rocks from the Rochester and Decew Formations, and of the Goat Island and Gasport Members of the Lockport Formation. The basal Rochester Formation consists of 0.30 m of shaly dolostone which is overlain by the Decew Formation, 1.22 m of a fine–crystalline, massive–and irregular–bedded dolostone. The Lockport Formation exposure is 7.43 m of a medium– to coarse– crystalline, fossiliferous dolostone (Gasport Member) and a subcrystalline, massive dolostone of the Goat Island Member.

### QUARRY OPERATION

The quarry is worked on a single lift of about 7.0 to 8.2 m. Drilling is carried out with a Gardner–Denver 123, on a 2.74 m x 2.74 m drill pattern with 7.6 cm diameter holes. Blasting conditions are dry and prilled ammonium nitrate is used as a bulk explosive. The blasted stone is loaded by one 992B Caterpillar loader onto three 50–ton Euclid trucks. The trucks haul approximately 700 m to the primary crusher at the Vineland crushing facilities.

A bridge to span the quarry floor has been constructed along Cherry Avenue, allowing the haul trucks to pass beneath between the Clinton and Vineland Quarry properties.

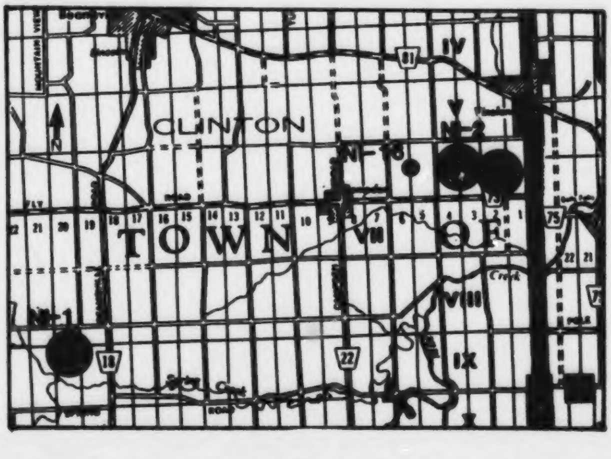


Figure NI-16-1. LOCATION MAP FOR CLINTON QUARRY.

## PROCESSING

Stone from the Clinton Quarry is processed at the Vineland Quarry (NI–2), and the process flow sheet is shown on Figure NI–2–3.

The primary crusher, a Jeffrey 536 impact unit, reduces the stone to –8 in. which is then fed by a 48 in. conveyor to a 6 ft. x 16 ft. double–deck screen. The screen produces Granular "A" and +4 in. –6 in. rubble rock, both of which are stockpiled by conveyor, and –8 in. material that is carried to a surge pile by a 42 in. conveyor. The surge pile material is recovered by a vibrating feeder onto a 36 in. tunnel conveyer that feeds a second 6 ft. x 16 ft. double–deck screen. This screen produces +1 1/2 in. oversize that is sent to a Symons 5 1/2 ft. cone crusher, –1 1/2 in. and +7/8 in. material sent to either a Penn or Jeffrey impact crusher, and –1/2 in. fines that are added to the output of the Symons cone crusher and fed to another 6 ft. x 16 ft. double–deck screen. This screen produces 3/4 in. clear, –5/8 in. granular stone and screenings. Stone crushed by the two impactors is screened by two parallel 7 ft. x 20 ft. double–deck screens that return +3/4 in. oversize for recrushing and feed the –3/4 in material to an 8 ft. x 22 ft. double–deck screen. This screen produces –3/4 in. +1/2 in. concrete stone and –1/2 in. material that is split by a 5 ft. x 12 ft. screen into –1/2 in. +3/16 in. chips and –1/4 in. screenings.

Different grades of concrete, asphalt and crusher run stone can be produced by varying the screen sizes.

## PRODUCTS

Vineland Quarries and Crushed Stone Ltd. has the capability to produce different grades of concrete, asphalt and crusher run stone by varying the screen sizes. Products include but are not restricted to, the following:

Rubble Rock
1 1/2 in. Granular
3/4 in. Granular
–5/8 in. Granular
3/4 in. Clear
3/8 in. Washed
1/8 in. Washed
–1/4 in. Washed
–3/4 in. + 1/2 in. Concrete Stone
Screenings
Manufactured Sand

## REFERENCES

None

## MAPS

None

# Part 2
# Southwestern Ontario

# Owen Sound District

## INTRODUCTION

Owen Sound District is the northernmost district in the Southwestern Ontario region and includes the Bruce Peninsula and most of Bruce and Grey Counties (Figure O–0–1). The district is bounded by Lake Huron, Georgian Bay, and the Districts of Huronia, Cambridge and Wingham.

Thirty–six quarries in Owen Sound District are documented in the Quarry Inventory (Appendix IV, Volume I); nine of these are currently active, two report intermittent production, and the balance represent past producing quarries of geological significance.

All of the active quarries, one intermittently active quarry (O–9) and one abandoned quarry (O–4) were visited during the study and include the following:

| | |
|---|---|
| *O–1* | *Arriscraft Corporation – Adair Marble Quarry (active)* |
| *O–2* | *Moor Developments Inc. Quarry (active)* |
| *O–3* | *Amsen Quarry Ltd. – Ross Quarry (active)* |
| *O–4* | *J. S. Cook – Cook Quarry (abandoned)* |
| *O–5* | *Owen Sound Ledgerock – Wiarton Quarry (active)* |
| *O–6* | *R. G. Ebel – Ebel Quarry (active)* |
| *O–7* | *C. E. McCartney – McCartney Quarry (active)* |
| *O–8* | *Owen Sound Ledgerock Ltd. – Owen Sound (Cruickshank) Quarry (active)* |
| *O–9* | *E.C. King Contracting – Tolhurst Quarry (intermittent)* |
| *O–10* | *E.C. King Contracting – Sydenham Quarry (active)* |

## REGIONAL GEOLOGY

The dominant geomorphic feature in the Owen Sound District is the Niagara Escarpment. In the northern half of the district, on the Bruce Peninsula, the Escarpment forms steep bluffs (up to 60 m high) along the Georgian Bay shoreline with exposed rock strata gently sloping to the west into Lake Huron. In this area the gently rolling and irregular bedrock surface is covered by a thin veneer of Quaternary deposits and wet swampy basins and lakes. In the southern half of the district, the Niagara Escarpment is less prominent and follows the Georgian Bay shoreline to the southeast. The Quaternary deposits become thicker and more varied, especially to the southwest. The Niagara Escarpment is indented by a number of northeast trending valleys, such as those at Colpoy's Bay, Owen Sound, Bighead River Valley, and the Beaver Valley.

Middle Ordovician to Middle Devonian strata are exposed in this district (see Figure O–0–2). The bluffs and caprock of the Niagara Escarpment consist of Silurian strata, and the Ordovician strata occur as a thin belt of recessively weathering units at the base of the Escarpment. The Devonian strata only underlie the extreme southwest corner of this district.

Current quarrying activities in the Owen Sound District are almost exclusively limited to Middle Silurian dolostones, which are extracted for building stone, landscaping stone, and aggregate. Historically, however, various units throughout the whole stratigraphic interval exposed in the district have been quarried, primarily for building stone.

The oldest strata exposed in the Owen Sound District are the black organic–rich calcareous shales and limestones of the Middle to Upper Ordovician Collingwood Member of the Lindsay Formation, which outcrop only in the extreme eastern end of the district.

The Lindsay Formation is overlain by the soft, grey, greenish–grey and bluish–grey fissile shales of the Upper Ordovician Blue Mountain Formation which outcrop in a narrow southeast trending belt.

The Blue Mountain Formation is overlain by the interbedded grey limestones and blue–grey shales of the Upper Ordovician Georgian Bay Formation. In the southeastern part of the district, this formation outcrops below the Escarpment in a relatively wide belt which narrows considerably to the north as the Georgian Bay Formation disappears into the subsurface approximately half–way up the Bruce Peninsula.

The uppermost Ordovician strata in this district are the predominantly red shales of the Queenston Formation. These overlie and may be interbedded with the blue–grey shales of the Georgian Bay Formation. The Queenston Formation thins to the north and pinches out north of the Bruce Peninsula.

The oldest Silurian strata in the Owen Sound District, the sandstones of the Lower Silurian Whirlpool Formation, are reported to occur only in the extreme southern portion of the district (Liberty and Bolton, 1971). The thin–bedded grey to blue–grey dolomitic limestones and dolostones of the Lower Silurian Manitoulin Formation overlie the Whirlpool Formation in the south and the Ordovician Queenston or Georgian Bay Formations in the remainder of the district. In some places the Manitoulin Formation forms a secondary escarpment below the main Niagara Escarpment. The Manitoulin Formation is intermittently quarried for aggregate at the Tolhurst Quarry (O–9) in Sarawak Township, Grey County.

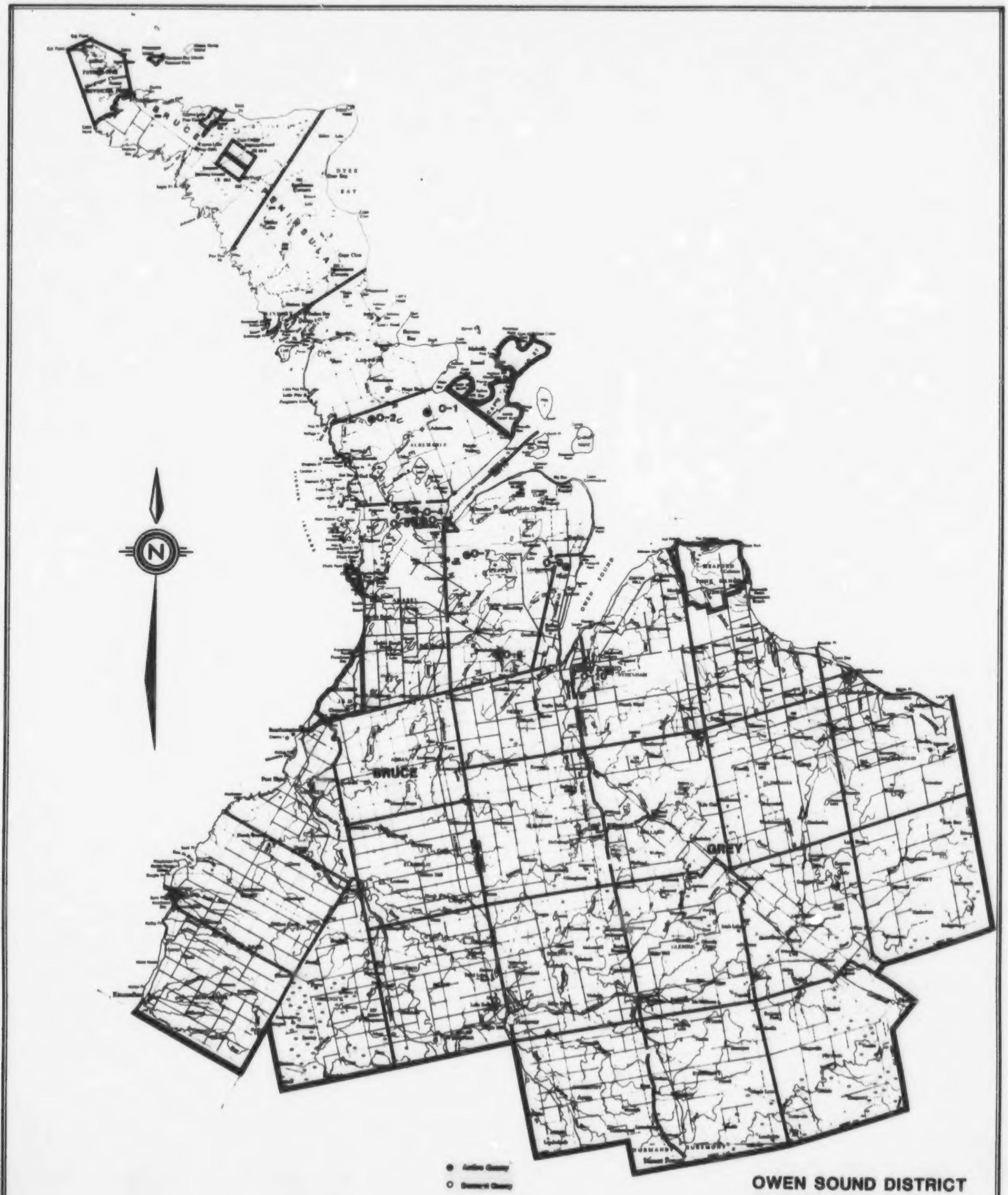

O-1
O-2
BRUCE
GREY
PENINSULA
ALBEMARLE
AMABEL
OWEN SOUND
N
Active Quarry
Dormant Quarry
OWEN SOUND DISTRICT
QUARRY LOCATION MAP

Figure O-0-1. OWEN SOUND DISTRICT QUARRY LOCATION MAP.

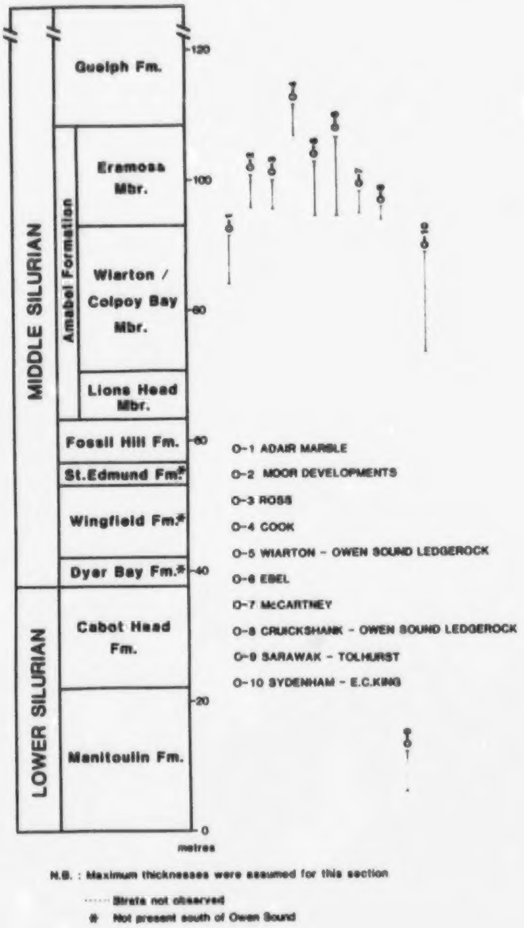

MIDDLE SILURIAN
LOWER SILURIAN
Amabel Formation
Guelph Fm.
Eramosa Mbr.
Wiarton / Colpoy Bay Mbr.
Lions Head Mbr.
Fossil Hill Fm.
St.Edmund Fm.*
Wingfield Fm.*
Dyer Bay Fm.*
Cabot Head Fm.
Manitoulin Fm.
120
100
80
60
40
20
0
metres
O-1 ADAIR MARBLE
O-2 MOOR DEVELOPMENTS
O-3 ROSS
O-4 COOK
O-5 WIARTON - OWEN SOUND LEDGEROCK
O-6 EBEL
O-7 McCARTNEY
O-8 CRUICKSHANK - OWEN SOUND LEDGEROCK
O-9 SARAWAK - TOLHURST
O-10 SYDENHAM - E.C.KING
N.B. : Maximum thicknesses were assumed for this section
...... Strata not observed
* Not present south of Owen Sound

**Figure O-0-2. STRATIGRAPHIC COLUMN SHOWING PRINCIPAL QUARRIES OF OWEN SOUND DISTRICT.**

The Manitoulin Formation is overlain by the green, grey, and red shales of the Lower Silurian Cabot Head Formation. Due to their recessive weathering characteristics these shales commonly occur in the Escarpment in relatively steep, vegetation covered slopes below the near vertical bluffs of overlying, more resistant, dolostones.

On the Bruce Peninsula (north of Owen Sound), the Cabot Head Formation is overlain by shales and dolostones of the Middle Silurian, Dyer Bay, Wingfield, and St. Edmund Formations (in ascending stratigraphic order). These are in turn overlain by the fossiliferous, buff- to grey-brown, thin-and irregular-bedded, fine- to coarse-crystalline dolostones of the Middle Silurian Fossil Hill Formation. South of Owen Sound, the Dyer Bay, Wingfield, and St. Edmund Formations are not present, and the Fossil Hill Formation directly overlies the Cabot Head Formation.

The Fossil Hill Formation is overlain by the dolostones of the Middle Silurian Amabel Formation which is subdivided into three members (in ascending order): the Lions Head, Wiarton/Colpoy Bay, and Eramosa Members. The Lions Head Member consists of thin-bedded, light buff, fine-crystalline dolostone. The thick- to massive-bedded Wiarton/Colpoy Bay Member consists of white weathering, grey to blue-grey, fine- to coarse-crystalline dolostone with local vuggy zones and variably developed blue mottling. This member forms the resistant white cliffs of the Niagara Escarpment on the Bruce Peninsula and forms a smooth undulating surface which slopes westward from the Escarpment face for several kilometres. Topographic highs of low relief on this surface are bioherms (reefs) in the Wiarton/Colpoy Bay Member. The Eramosa Member consists of grey-brown to black, thin-bedded, laminated, fine-crystalline, generally bituminous dolostone, interbedded with light brown, thin- to thick-bedded, weakly bituminous dolostone. The Eramosa Member is interpreted to be an inter-reefal facies associated with bioherms in the Wiarton/Colpoy Bay Member (or bioherms at the base of the overlying Guelph Formation). The Eramosa Member is absent where Wiarton/Colpoy Bay Member bioherms grade up into Guelph Formation bioherms.

The Wiarton/Colpoy Bay Member hosts two currently active quarries. It is quarried for building stone at the Adair Marble Quarry (O-1) in Albemarle Township and for aggregate at the E. C. King Quarry (O-10) in Sydenham Township near Owen Sound.

Building and landscaping stone are currently excavated from the Eramosa Member at six quarries (O-2, O-3, O-5, O-6, O-7, and O-8) on the Bruce Peninsula. A seventh quarry in the Eramosa Member, the Cook Quarry (O-4) near Wiarton, is presently abandoned, but because of its historical and geological significance (it exposes the upper contact of the Eramosa Member with the Guelph Formation), it has been included in this report.

The Middle Silurian Guelph Formation overlies the Amabel Formation and occurs in a broad belt west of the Niagara Escarpment, from the central and western areas of the Bruce Peninsula, across the district to the southwest. The Guelph Formation is typically a light brown, fine- to medium-crystalline, thin- to thick-bedded dolostone with minor thin bands of wispy dark brown stylolites and local vuggy zones. Bioherms are common in the Guelph Formation and typically form low ridges on the western side of the Bruce Peninsula.

In the southwestern part of the Owen Sound District, the Guelph Formation is overlain by the poorly exposed Upper Silurian Salina and Bass Islands Formations. In this district the Salina Formation consists of alternating grey dolostone, green shale, brown dolostone, and red shale, and the Bass Islands Formation consists of cream to brown, fine-crystalline, thin- to thick-bedded dolostones.

In the extreme southwestern corner of the district, Middle Devonian strata which include (in ascending stratigraphic order) the Bois Blanc Formation and the Detroit River Group (Amherstberg and Lucas Formations), disconformably overlie the Upper Silurian strata. Although these units consist of limestones and dolostones they are not currently quarried by the limestone industry in this district.

### LIMESTONE INDUSTRIES

The principal limestone industries in Owen Sound District are building stone and aggregates. Fertilizer grit, glass grade dolostone, agricultural lime and coarse mineral fillers are also produced at the Sydenham Quarry (O-10).

Stone production in 1986 from Bruce County totalled 106,141 tonnes, from five active building stone quarries (O-1, O-2, O-3, O-5 and O-6). Stone production in 1986 from Grey County totalled 204,000 tonnes from two building stone (O-7, O-8) and two aggregate quarries (O-9, O-10).

The largest producing operation was E. C. King Contracting – Sydenham Quarry (O-10), which produces a variety of sizes of aggregate stone, including that used by its subsidiary Owen Sound Dolomite for the production of agricultural lime and fillers.

## O-1 ARRISCRAFT CORPORATION – ADAIR MARBLE QUARRY

### LOCATION AND OWNERSHIP

The Adair Marble Quarry is located 2.5 km south of Hope Bay on Bruce County Road 9, in Lots 7 and 8, Concession 8, Albemarle Township, Bruce County (Figure O-1-1). The licensed area of the quarry is 64 ha. In 1987 it was being worked on a continuous basis by Adair Marble Quarries, a division of Arriscraft Corporation, and quarry blocks of the Silurian dolostone were being trucked to the company's dressing plant at Cambridge, Ontario (site CB-14, Cambridge District). Building stone from this quarry has been used on the new Ottawa Courthouse, the restoration of the Rideau Locks #1-5 in Ottawa, and the Canadian Chancery in Washington, D.C. The present quarry was opened in 1979 to replace an earlier operation owned by Arriscraft in Lot 4, about 1 km to the north. The former "Adamsville" and "Scott" quarries, inactive since the 1950s, were worked in Lot 8. The present capacity is approximately 30,000 tonnes per year.

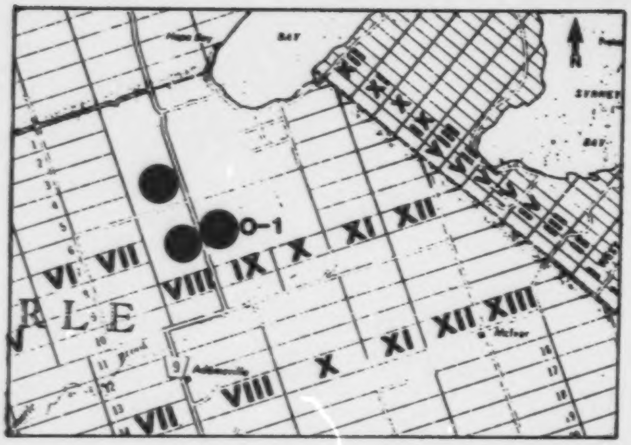


Figure O-1-1. LOCATION MAP FOR ADAIR MARBLE QUARRY.

The original quarry in Lot 4, Concession 8, was opened and briefly operated by R. G. Ebel. In 1968 it was acquired by Angelstone Limited and was worked continuously until 1979, producing mill blocks at the rate of about 10,000 tonnes per year. In 1971 the original quarry was reported (Hewitt and Vos, 1972, p.46) to be developed on three levels of nearly 2 m each. The quarry is now licensed for 6 ha.

### GEOLOGY

This quarry consists of three excavations, which expose a total of approximately 7 m of the Wiarton/Colpoy Bay Member of the Middle Silurian Amabel Formation. The bedrock surface is irregular, glacially scoured and fluted (fluting may in part follow irregular bedding planes), and therefore overburden varies in thickness from 0 to 3 m. Large mill blocks (approximately 4 cu. m) are drilled off in approximately three lifts, each up to 2 m thick. Lifts are taken along natural bedding planes which are planar to undulating.

The Wiarton/Colpoy Bay Member, as exposed in this quarry, is a light grey to white, fine- to coarse-crystalline dolostone with attractive blue-grey mottles, and local vuggy zones. Blocks containing concentrations of vugs are generally discarded. Shale partings and disseminated pyrite crystals are virtually absent. Occasional stylolites may form lines of weakness. Large areas are virtually free of joints, but scattered vertical east-west jointing is present at intervals of 3 m to 5 m.

The Wiarton/Colpoy Bay Member was not subdivided into further units in this quarry. The lithology is

**Photo 0-1-1.**
**BEDDING IRREGULARITIES IN WIARTON/COLPOY BAY MEMBER (AMABEL FORMATION); ADAIR MARBLE QUARRY.**

similar to that exposed in the two inactive Arriscraft quarries in the area.

### Geological Section

*Thickness*

*UNIT 1 Amabel Formation, Wiarton/Colpoy Bay Member 7.0m*

Dolostone: white to light grey with blue-grey mottles, weathers light grey; fine to coarse crystalline; medium to thick bedded, with planar to undulating contacts; abundant fossil fragments (crinoids, corals); vugs (up to 5 cm in diameter) occur scattered throughout or concentrated in vuggy zones and are usually calcite rimmed or filled; mottles vary in abundance (5 -50%) and vary in shape from irregular to planar and parallel to bedding; fluted, glacially scoured subcrop surface.

*Total thickness 7.0m*

### QUARRY OPERATION

The active Adair Marble Quarry is largely in Lot 7 and is worked on three levels over an area of 300 m by 100 m. Each level varies in thickness up to about 2 m. The top level is particularly variable because of an undulating glaciated surface. Air drills are mounted in pairs on 3 m beams which travel on horizontal quarry bars (of the company's own design) up to 7.5 m long. Final splitting of the mill block from the face is accomplished by hydraulic plug and feather equipment capable of pressures of 55 MPa (8,000 p.s.i.), or rarely by light blasting. Compressed air for the drills is provided by two electrically powered Joy screw compressors which are housed in a portable trailer. Mill blocks are taken from the face and loaded onto flat-bed trucks by a rubber-tired Clark #275 forklift.

In 1987, 25 men were employed and the quarry was operated on a 24-hour, 5 days per week basis. Drilling averaged 15,000 m to 20,000 m per week. Substantial quarry wastage was the result of shipping only uniform-sized blocks, ideally 235 cm by 185 cm by 80 cm, weighing about 10 tonnes. Blocks of this size were most efficiently slabbed by the circular saws in use at the Cambridge, Ontario, fabrication plant. Smaller blocks re-

**TABLE O-1-1. WIARTON/COLPOY BAY DOLOSTONE, PHYSICAL PROPERTIES.**

| | | (1)Adair Marble | (2)Scott Quarry |
|---|---|---|---|
| Average compressive strength | MPa | 181.7 | 130.8 |
| | p.s.i. | 26,344 | 18,958 |
| Abrasive hardness | | 11.08 | 19.7 |
| Modulus of rupture | MPa | 12.4 | |
| | p.s.i. | 1,797 | |
| Absorption | % | 0.71 | 0.93 |
| Bulk specific gravity | | 2.68 | 2.63 |
| Weight per unit volume | kg per $m^3$ | 2,677 | 2,629 |
| | lbs. per $ft.^3$ | 167.2 | 164.2 |

*Sources:*
*(1) Warnock Hersey; Arriscraft Corporation.*
*(2) Hewitt, 1964b, p. 22.*

quired the same amount of time and effort but yielded fewer marketable slabs. The company has an extensive stone fabrication shop in Cambridge with modern stone shaping, sizing and hole-drilling capabilities.

Mill blocks are delivered to Arriscraft Corporation's Cambridge plant by truck, a distance of about 200 km.

### REFERENCES

Hewitt, 1964b, p. 22
Hewitt and Vos, 1972, p. 46
Kanarek, 1986

## O-2 MOOR DEVELOPMENTS INC. QUARRY

### LOCATION AND OWNERSHIP

The quarry is located 1.5 km west of Highway 6, about 17 km north of Wiarton in Lot 3, Concession I EBR, Albemarle Township, Bruce County (Figure O-2-1). Licensed area of the site is 40.5 ha. From 1974 to 1982 it was operated under the name of Rouse Quarries Ltd., and in 1982 it was acquired by Clearstone Quarries Industries Inc. (but was inactive during 1983 and 1984). The quarry was reopened in 1985 by Bruce Marble and Stone Corporation and was subsequently taken over by Moor Developments Inc. in late 1986. The quarry is operated eight months of the year from March to November with a work force of ten. The quarry is briefly described by Hewitt (1964b, p. 19).

### GEOLOGY

Quarrying in at least five small excavations at this site has exposed about 5 m of section consisting of two units of the Eramosa Member of the Amabel Formation (Figure O-2-2). The lower unit is similar to Eramosa Member strata exposed in other quarries on the Bruce Peninsula, except that it is lighter in colour, less bituminous, locally more vuggy, appears finer grained, and is more stromatolitic. Although the upper unit is similar in character to strata of the Guelph Formation exposed in the vicinity, mapping in other quarries on the Bruce Peninsula (e.g. O-5 and O-6) indicates that this unit is a "Guelph-like" interbed within the Eramosa Member.

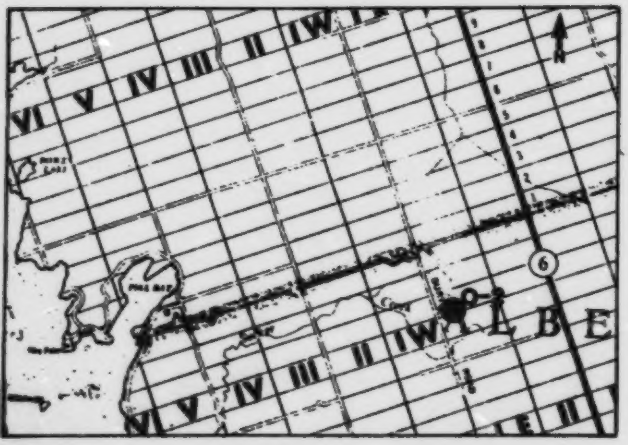


**Figure O-2-1. LOCATION MAP FOR MOOR DEVELOPMENTS INC. QUARRY.**

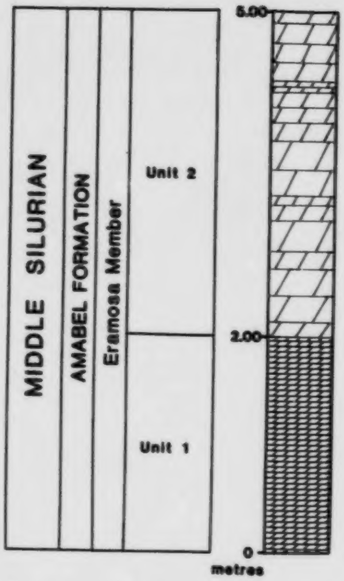


**Figure O-2-2. STRATIGRAPHIC COLUMN FOR MOOR DEVELOPMENTS INC. QUARRY.**

Abundant domal to linear (oriented roughly northwest) anticlinal features exposed on the property may be related to underlying Amabel Formation bioherms. Generally, horizontal parting separations on the tops of the domes are more abundant and closely spaced, whereas partings in the interdomal areas occur less frequently. Two joint sets are present in the quarry trending 074° and 335- 340° with average spacings of 1 to 3 m. Glacial overburden is generally less than 1 m thick on the property.

### Geological Section

*Thickness*

*UNIT 2 Amabel Formation, Eramosa Member* *3.0m*

**Dolostone: light grey-brown to light brown, weathers buff-brown, fine to medium crystalline; thin to thick bedded, with irregular to planar contacts which are generally related to thin bands of wispy dark brown styolites; rare silicified corals and crinoidal fragments; calcite mineralization occurs in scattered vugs; lower contact of the unit is sharp, at the top of a thin shaly bituminous bed.**

Photo O-2-1. THIN-BEDDED LAMINATED DOLOSTONE OF UNIT 1 AT MOOR QUARRY.

*UNIT 1 Amabel Formation, Eramosa Member* *2.0m*

Dolostone: light grey to light grey-brown, weathers light grey to light buff-brown; very fine to fine crystalline; laminated to thin bedded with planar to wavy and locally crenulated contacts; calcite, pyrite and fluorite mineralization in local vugs; locally stromatolitic; thin bituminous partings throughout.

*Total thickness* *5.0m*

### QUARRY OPERATION

The main quarry excavation is in Unit 1 and is worked on a single bench over an area 100 m by 30 m. Jointing is not a particular problem in quarrying, but rolls in the Eramosa caused by underlying reefs are responsible for curved bedding planes and variable parting separations.

Quarrying is accomplished with bars and wedges and occasionally plug and feather techniques. Slabs are lifted by front-end loader or forklift and carried to storage for subsequent cutting and polishing as desired. There are three guillotines and one gang saw plus polishing equipment at the quarry. The company produces a variety of thin Eramosa rock products, plus sawn and polished sills, copings, ashlar, interior slabs, and table tops. Sills are marketed in 15 cm and 25 cm thicknesses; copings in 25 cm, 30 cm, 35 cm, 40 cm, 45 cm, and 50 cm thicknesses; flagstone in 5 cm thickness and marble slabs in 2 cm thickness.

### REFERENCES

Hewitt, 1964a, p. 59
Hewitt, 1964b, p. 19

## O-3 AMSEN QUARRY LTD. — ROSS QUARRY

### LOCATION AND OWNERSHIP

This building stone quarry is located in Lots 10 and 11, Concession 25, Amabel Township, Bruce County, 5.7 km northwest of Wiarton on a sideroad north of Oliphant Road (Figure O-3-1). The quarry license covers 40.5 ha.

The active Ross Quarry (located in Lot 11) was opened in 1970 by Donald R. Ross. On March 1, 1987, the quarry was sold to Franc and Georgina Amsen and is currently operated by W. R. McKendrick. The Smithson Quarry (located in Lot 10) is just east across the sideroad from the Ross Quarry. Although licensed for 9.3 ha, the Smithson Quarry has been inactive since 1980.

### GEOLOGY

The quarry excavations expose up to 4 m of the Eramosa Member of the Amabel Formation which is subdivided into two units in this quarry. The lower unit, a laminated, thin-bedded light grey-brown dolostone, is the main source for building stone products in the quarry. The upper unit, a thin- to medium-bedded, nonlaminated, locally vuggy, light brown dolostone is not unlike the dolostones of the overlying Guelph Formation. Exposures of the Eramosa Member in nearby quarries on Oliphant

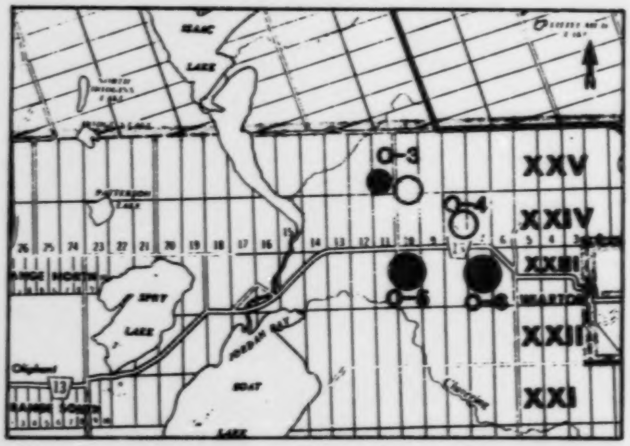


Figure O-3-1. LOCATION MAP FOR ROSS QUARRY.

Photo O-3-1.
CUTTING UNIT 1 OF ERAMOSA MEMBER WITH A DIAMOND SAW AT ROSS QUARRY. A THIN LAYER OF LIGHTER, UNIT 2 OVERLIES UNIT 1.

Road (quarries O-5 and O-6), indicate that this unit is in fact an interval of "Guelph-like" lithology within the Eramosa Member and not the true Guelph Formation. The thickness of this upper unit varies somewhat over the quarry property due to an irregular bedrock surface.

The strata in this quarry exhibit low amplitude warping and rolls. There are two main vertical joint sets in the quarry, that trend approximately 360° and 74°-80° with spacings of 2 m to 4 m. Glacial overburden is generally less than 1 m thick.

### Geological Section

| | | *Thickness* |
|---|---|---|
| *UNIT 2* | *Amabel Formation, Eramosa Member* | *2.0m* |
| | **Dolostone: light grey-brown to light brown, weathers buff-brown; fine to medium crystalline; thin to medium bedded, with planar to irregular contacts; rare corals and crinoidal fragments; calcite mineralization present in local vugs; lower contact of unit is sharp.** | |
| *UNIT 1* | *Amabel Formation, Eramosa Member* | *2.0m* |
| | **Dolostone: light grey-brown to brown, weathers light grey to light grey-brown; very fine to fine crystalline; laminated to thin bedded, with planar to slightly wavy contacts; minor stromatolitic laminae throughout and especially in the top 1 to 3 cm.** | |
| *Total thickness* | | *4.0m* |

## QUARRY OPERATION

The Ross Quarry is 200 m by 200 m with a working depth of 3 m on 4 benches, and is operated by a work force of 20 men.

The quarry produces a variety of stone products including natural cut flagstone, random flagstone, drywall stone and ashlar coursing. Dimension stone will be produced in April of 1988. Much of the production is sawn in place and subsequently lifted by bars and wedges. Powered equipment includes a portable electric diamond saw, a small forklift and a hydraulic guillotine.

The currently inactive, adjacent Smithson Quarry is 60 m by 30 m and about 3 m deep. Although the jointing pattern is similar in both quarries, numerous fractures in the Smithson Quarry render much of the stone unusable. Stone products produced there were similar to those from the Ross Quarry.

### Quarry Equipment

3 – portable electric diamond-tipped saws
1 – 36" diameter diamond-tipped saw
1 – 60" diameter diamond-tipped saw in operation May 1, 1988
1 – Gangsaw
3 – Guillotine 48" tooth
1 – Guillotine for cobble stone production
1 – Multi-blade cut-off saw
2 – Front-end loaders
1 – Forklift

## REFERENCES

None

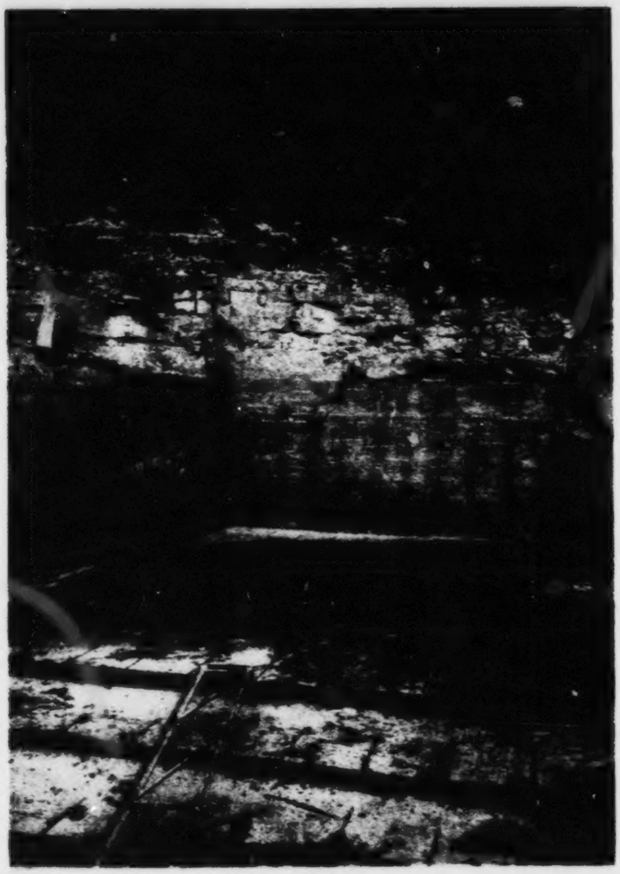


Photo O-3-2. MEDIUM-BEDDED DOLOSTONE OF UNIT 2 OVERLYING THIN-BEDDED DOLOSTONE OF UNIT 1, BOTH OF THE ERAMOSA MEMBER; ROSS QUARRY.

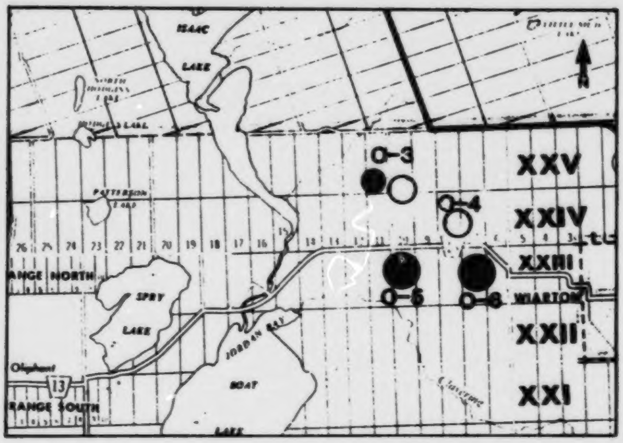

ISAAC
LAKE
PATTERSON LAKE
O-3
O-4
XXV
XXIV
XXIII
O-6
O-8
WIARTON
XXII
XXI
26
25
24
23
22
21
20
19
18
17
16
15
13
14
12
11
10
9
6
5
4
3
RANGE NORTH
SPRY
LAKE
JORDAN BAY
Oliphant
13
RANGE SOUTH
BOAT
LAKE

Figure O-4-1. LOCATION MAP FOR COOK QUARRY.

## O-4 J.S. COOK — COOK QUARRY

### LOCATION AND OWNERSHIP

The Cook Quarry is an abandoned building stone quarry located in Lots 7 and 8, Concession 24, Amabel Township, Bruce County, on the north side of Oliphant Road, 3.2 km west of the Town of Wiarton (Figure O-4-1).

### GEOLOGY

This quarry exposes 2.6 m of the Eramosa Member of the Amabel Formation and approximately 2.0 m of the overlying Guelph Formation (Figure O-4-2). The Eramosa Member consists of interbedded dark brown, laminated, bituminous dolostones and thin to medium-bedded, light to dark brown dolostones. The thick-bedded, massive-textured, light brown Guelph Formation dolostones are exposed in old workings northwest of the main excavation. Ridges up to 10 m high, of biohermal rocks of the Guelph Formation, outcrop north of the quarry excavations.

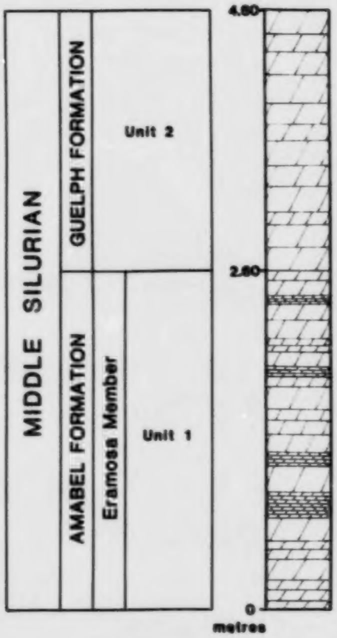

MIDDLE SILURIAN
GUELPH FORMATION
AMABEL FORMATION
Eramosa Member
Unit 2
Unit 1
4.60
2.60
0
metres

Figure O-4-2. STRATIGRAPHIC COLUMN FOR COOK QUARRY.

The strata exposed in this quarry overlie that of the Ebel and Owen Sound Ledgerock Quarries (O-6 and

O–5, respectively) and are equivalent to the rocks exposed in the adjacent, abandoned Bruce Peninsula Stone Quarry (*see* Appendix IV, Volume I). The glacial overburden thickness in the Cook Quarry is generally less than 0.5 m.

### Geological Section

| | *Thickness* |
|---|---|
| *UNIT 2 Guelph Formation* | *2.0m* |
| Dolostone: light grey-brown to light brown, weathers buff-brown; fine to medium crystalline; medium to massive bedded; sparsely fossiliferous with scattered corals and large brachiopods; underlying or interbedded with biohermal build-ups to the north; bioherms contain an assemblage of abundant large brachiopods, corals, stromatoporoids, and other fossils; lower contact is not well exposed. | |
| *UNIT 1 Amabel Formation, Eramosa Member* | *2.6m* |
| Interbedded bituminous dolostones: (a) light to dark brown, weathering light grey-brown; fine to medium crystalline; thin to medium bedded; with variable bitumen content; abundant small brachiopods in some beds; and (b) dark brown to black, weathers dark grey-brown; fine to medium crystalline; laminated to thin bedded; bituminous. | |
| *Total thickness* | *4.6m* |

### REFERENCES

Parks, 1912, p. 261
Goudge, 1938, p. 206
Hewitt, 1960, p. 126
Hewitt, 1964a, p. 59
Hewitt, 1964b, p. 15
Liberty and Bolton, 1971, p.46
Hewitt and Vos, 1972, p. 49

### MAPS

Caley, 1945b, GSC Map 45–18
Liberty, 1966, GSC Map 19–1965
Liberty and Bolton, 1971, GSC Map 1194A

## O–5 OWEN SOUND LEDGEROCK — WIARTON QUARRY

### LOCATION AND OWNERSHIP

This building stone quarry is located in Lots 10 and 11, Concession 23, Amabel Township, Bruce County, south of Oliphant Road, and 4.1 km west of Wiarton (Figure O–5–1). The licensed area is 44.9 ha. The quarry supplies an area from Detroit to Montreal and Ottawa.

### GEOLOGY

The quarry is situated on the south flank of a hill (bedrock high). Excavation of the quarry has exposed up to 6.3 m of the Eramosa Member of the Amabel Formation, with an additional 2.0 m of this member exposed in outcrops at the south end of the property.

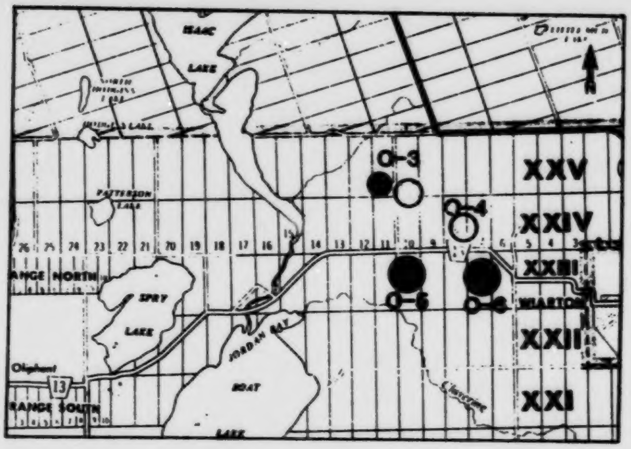


Figure O–5–1. LOCATION MAP FOR WIARTON QUARRY.

The Eramosa Member in this quarry can be subdivided into three units in the main excavation, with a lower fourth unit exposed in the interval below and south of the quarry. The lowermost unit exposed in the quarry (unit 2), locally termed the "Marble" beds, occurs in other Eramosa Member quarries in the vicinity. The uppermost unit (unit 4) contains locally abundant chert nodules or beds, is generally more bituminous than the other units and exhibits extreme warping, which may be related to a stromatolitic bioherm that outcrops north of the quarry. Two main joint sets occur in the quarry and trend at 75–85° and 335–345° with 1 to 3 m spacing. Glacial overburden is generally less than 0.5 m thick.

The stratigraphy exposed in this quarry can be correlated with that exposed in the Ebel Quarry (O–6), 1.3 km to the east. Owen Sound Ledgerock also owns a currently inactive, licensed property (*see* site O–15, Appendix IV, Volume I) on the north side of Oliphant Road, which exposes rocks stratigraphically above this quarry (possibly into the Guelph Formation).

TABLE O-5-1. ERAMOSA MEMBER DOLOSTONE, PHYSICAL PROPERTIES.

| | | | |
|---|---|---|---|
| Compressive strength, | MPa | Maximum | 123 |
| | | Minimum | 120 |
| | | Average | 122 |
| Absorption | | | 1.62% |
| Bulk specific gravity, | | | 2.53 |
| Weight per unit volume, | PSI | | 158 |
| | kg/cu. m | | 2,530 |
| Abrasive hardness | | | 18.1 |

*Source: Hewitt, 1964b, p.18.*

**Photo O-5-1. INTERBEDDED LIGHT BROWN AND BLACK DOLOSTONES OF UNIT 4. (ERAMOSA MEMBER - AMABEL FORMATION); WIARTON QUARRY.**

## Geological Section

*Thickness*

*UNIT 4 Amabel Formation, Eramosa Member* *2.4m*

Interbedded bituminous dolostones: (a) light to dark brown, weathers buff- brown; fine to medium crystalline; thin to medium bedded; with variable bitumen content; and (b) dark brown to black, weathers dark grey-brown; fine to medium crystalline; laminated to thin bedded; bituminous.

For both (a) and (b): bed thicknesses vary laterally and bedding is significantly warped at the north end of the property; some chert nodules and beds; pyrite occurs disseminated and with calcite infilling vugs and burrows; sphalerite is associated with a stromatolitic mound at north end of property; abundant small brachiopods in some beds; rare graptolites, cephalopods, corals, eurypterids, and stromatolites; some bedding planes with burrows and trails; the lower contact of the unit is taken at the base of the lowest dark brown to black laminated bed.

*UNIT 3 Amabel Formation, Eramosa Member* *2.4m*

Dolostone: light grey-brown to light brown, weathers buff-brown, fine to medium crystalline; thin to thick bedded with planar to slightly irregular contacts; calcite occurs in small (<5 cm) vugs scattered throughout and locally in vuggy bands; sparsely fossiliferous with rare corals and crinoidal fragments; lower contact of unit is sharp.

**Photo O-5-2. PARK HYDRASPLIT GUILLOTINE AT WIARTON QUARRY.**

*UNIT 2 Amabel Formation, Eramosa Member* *3.0m*

Dolostone: light grey to grey-brown, weathers light grey-brown; very fine to fine crystalline; laminated to thin bedded with planar to wavy contacts and locally significant bituminous partings (especially in the uppermost beds); occasional stromatolitic laminae, especially abundant in the lower 1 m and uppermost 1 to 3 cm; local soft sediment deformation features; lower contact of unit is sharp.

*UNIT 1 Amabel Formation, Eramosa Member* *0.5m*

Dolostone: light grey-brown to light brown, weathers grey to buff-brown; fine to medium crystalline; thin to medium bedded, with bedding related to thin bands of wispy dark brown stylolites.

*Total thickness* *8.3m*

## QUARRY OPERATION

Horizontal bedding planes provide flat quarry floors in most places except for a single broad synclinal roll which creates slightly uneven floors in one part of the quarry. Three shallow benches are worked.

The stone is quarried by cutting with portable electric diamond saws, or simply by raising the layers by forklift. An air compressor, Darda hydraulic rock splitter, and plug and feather equipment are also used.

Stone is dressed using a large Park Hydrasplit guillotine, capable of splitting stone 2 m wide and 35 cm thick, using its 270 tonne breaking capacity. Products include 1 cm to 5 cm thick flagstone, and randomly sized, eroded and vuggy landscape stone. Some stone is also shipped to the Owen Sound plant (O–8) for sawing. In 1986, waste rock from past years was being crushed and trucked from the quarry under contract for aggregate uses.

### REFERENCES

Hewitt, 1964b, p. 18
Hewitt and Vos, 1972, p. 55

## O–6 R.G. EBEL — EBEL QUARRIES

### LOCATION AND OWNERSHIP

This quarry is located on the south side of Oliphant Road, 3 km west of Wiarton. The property includes parts of Lots 6, 7 and 8 in Concession 23 (the quarry is largely in Lot 7), Amabel Township, Bruce County (Figure O–6–1). The property is owned and operated by R. Griffith Ebel. The quarry licence covers an area of 12.1 ha.

### GEOLOGY

The rock in this quarry was deposited on the south side of a protecting reef and exposes an exceptional number of undisturbed strata.

Excavations in this quarry have exposed up to 7 m of flat–lying dolostones of the Eramosa Member of the Amabel Formation, with a further 5 m of this member exposed in outcrop below and south of the quarry (Figure O–6–2).

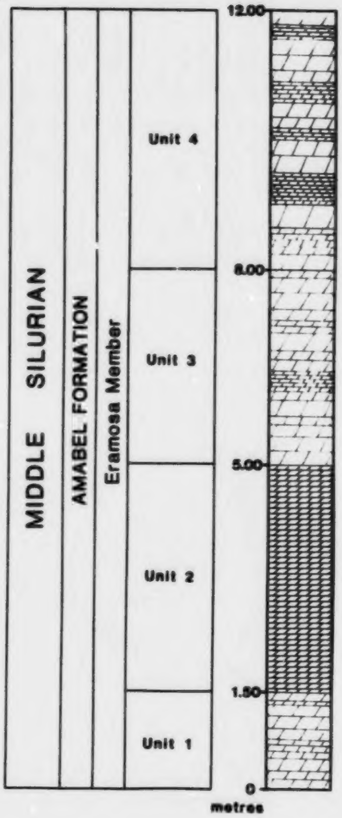


**Figure O–6–2. STRATIGRAPHIC COLUMN FOR EBEL QUARRIES.**

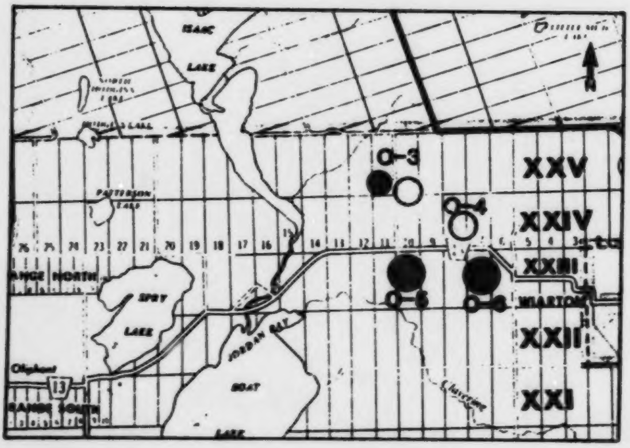


**Figure O–6–1. LOCATION MAP FOR EBEL QUARRIES.**

The Eramosa Member in this quarry can be subdivided into two units in the main excavation (units 4 and 3), with two additional units (units 2 and 1) exposed in outcrop to the south. Overlying strata, including the Amabel (Eramosa)/Guelph Formation contact, are exposed on the north side of Oliphant Road in the abandoned Bruce Peninsula Stone Quarry (*see* site O–16, Appendix IV, Volume I) and Cook Quarry (O–3) and the Charles Ebel Quarry. Although the uppermost unit in the Ebel Quarry is correlative with the upper unit (4) of the Owen Sound Ledgerock Quarry (O–5), the former is more extensive, contains less chert and does not exhibit the severe warping of the latter. Vertical jointing is widely spaced on both north–south and east–west diretions, the latter spaced at 2 to 10 m. Quaternary overburden in this quarry is generally less than 0.5 m thick.

### Geological Section

*Thickness*

*UNIT 4 Amabel Formation. Eramosa Member* *4.0m*

Interbedded bituminous dolostones: (a) light to dark brown, weathering buff-brown; fine to medium crystalline; thin to medium bedded with variable bitumen content; and (b) dark brown to black, weathers dark grey-brown; fine to medium crystalline; laminated to thin bedded; bituminous.

For both (a) and (b): local chert as nodules (some with sphalerite), in beds, and replacing fossils; vugs filled with calcite and pyrite; abundant small brachiopods in some beds, rare stromatoporoids, eurypterids and cephalopods; a few bedding planes with burrows and trails; lower contact of unit is at base of lowest dark brown to black laminated bed.

*UNIT 3 Amabel Formation, Eramosa Member* *3.0m*

Dolostone: light grey-brown to light brown, weathers buff-brown; fine to medium crystalline; thin to medium bedded, with planar to slightly irregular contacts which are generally related to thin bands of dark brown stylolites; calcite occurs as vug infills; small (<5 cm) vugs occur scattered throughout and locally in bands; sparsely fossiliferous with rare crinoidal fragments, stromatoporoids, and corals; lower contact of unit is sharp.

*UNIT 2 Amabel Formation, Eramosa Member* *3.5m*

Dolostone: light grey to grey-brown, weathers light grey-brown; very fine to fine crystalline; laminated to thin bedded with planar to wavy contacts and locally significant bituminous partings; local soft sediment deformation structures; stromatolitic beds locally present (especially in the lowermost beds); lower contact is sharp.

*UNIT 1 Amabel Formation, Eramosa Member* *1.5m*

Dolostone: light grey-brown to light brown, weathers grey- to buff-brown; fine to medium crystalline; thin to medium bedded with planar to slightly irregular contacts which are related to thin bands of wispy dark brown stylolites; small (<5 cm) vugs are locally abundant and filled with calcite and pyrite.

*Total thickness* *12.0m*

### QUARRY OPERATION

The quarry covers an area about 400 m by 50 m and is worked on three shallow benches. Quarrying of the thin Eramosa beds is accomplished by cutting with three portable diamond circular saws and lifting the slabs with bars and forklift. A Massey Ferguson front end loader can be equipped with either a 7 yd. bucket or 2 m forks, and it is capable of handling an 11-tonne load. A smaller (3 yd.) loader is also available. These loaders serve the multiple functions of overburden and waste removal, plus the lifting and transport of quarried slabs to the finishing plant.

**TABLE O-6-1. ERAMOSA MEMBER DOLOSTONE, PHYSICAL PROPERTIES.**

| | | | |
|---|---|---|---|
| Compressive strength, | MPa | Maximum | 171 |
| | | Minimum | 136 |
| | | Average | 158 |
| Absorption | | | 1.20% |
| Bulk specific gravity, | | | 2.60 |
| Kg per cubic metre | | | 2,605 |
| Abrasive hardness | | | 27.1 |

*Source: Hewitt, 1964b, p.15.*

### PROCESSING

At the finishing plant the thicker stone is guillotined into sills, cobbles, steps, mantles and random ashlar in thicknesses of 6 cm to 20 cm. Thinner stone is cut into paving tiles of various sizes: 125 mm thick and 50 cm square, 50 mm thick and 19 cm square, plus random flagstone. An attractive "walnut marble" can be fashioned from dark brown stone by slabbing slightly across the laminations and polishing the exposed face.

### PRODUCTS

Copings
Steps (50 mm to 200 mm thick)
Paving tiles 125 mm thick and 50 cm square
    50 mm thick and 19 cm square
Random flagstone
Cut flagstone (25 mm to 50 mm thick (30 cm to 90 cm rectangular))
Cobbles
Mantels and hearthstones
Flooring tiles (10 mm to 20 mm thick)
Large black or tan slabs for marble

### REFERENCES

Hewitt, 1960, p. 126
Hewitt, 1964a, p. 58
Hewitt, 1964b, p. 13
Hewitt and Vos, 1972, p. 50

### MAPS

Caley, 1945b, GSC Map 45-18
Liberty, 1966, GSC Map 19-1965
Liberty and Bolton, 1971, GSC Map 1194A

## O-7 C.E. McCARTNEY QUARRY

### LOCATION AND OWNERSHIP

Since 1970, dolostones of the Eramosa Member have been quarried solely for flagstone in this small quarry in part of Lots 7, 8 and 9, Concession 18, Keppel Township, Grey County (Figure O-7-1). The quarry is located 8 km south of Wiarton, about 3 km east of Highway 6 and is licensed for 12.5 ha. Two men are employed for a six month season from May to October.

### GEOLOGY

This quarry exposes up to 3.4 m of the Eramosa Member of the Amabel Formation in three small excavations (1

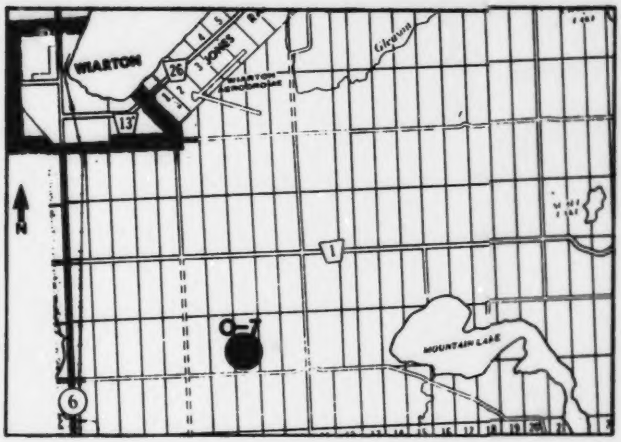


Figure O-7-1. LOCATION MAP FOR McCARTNEY QUARRY.

m of this interval is exposed in an exploratory excavation). The uppermost of the two units present, a buff–brown, medium– to thick–bedded dolostone, is exposed in all three excavations although it is not present (due to erosion) in the northern half of the property. The lower unit, a grey–brown, laminated dolostone, quarried for flagstone, is similar in lithology to the locally termed "Marble" beds found in other Eramosa Member quarries on the Bruce Peninsula.

The strata in this quarry exhibit broad low amplitude warping. Two vertical joint sets are present in the quarry, trending 350 to 360° and 65 to 85° with 1 to 3 m spacing. Glacial overburden is generally less than 1 m thick.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 2 Amabel Formation, Eramosa Member* | *1.2m* |
| Dolostone: light brown, weathers buff–brown; fine to medium crystalline; thin to medium bedded, with planar to irregular contacts; calcite infills locally abundant small (<5 cm) vugs; lower contact of unit is sharp. | |
| *UNIT 1 Amabel Formation, Eramosa Member* | *2.2m* |
| Dolostone: light grey to grey–brown; very fine to fine crystalline; laminated to thin bedded, with some wavy contacts; thin bituminous partings (especially in the uppermost 30 cm); thin stromatolitic laminae in uppermost few centimetres. | |
| *Total thickness* | *3.4m* |

### QUARRY OPERATION

The quarry is small, about 35 m by 15 m and is worked on a single 2 m bench. A thin layer of medium–bedded dolostone (Unit 2) at the top of the section is sometimes saved for general gardening and rockery stone. The dolostone of Unit 1 is quarried with bars and wedges and is stacked in random sizes on wooden pallets for subsequent handling by forklift. Two forklifts comprise the only quarry equipment other than the manual tools used in removing the flagstone from the working face.

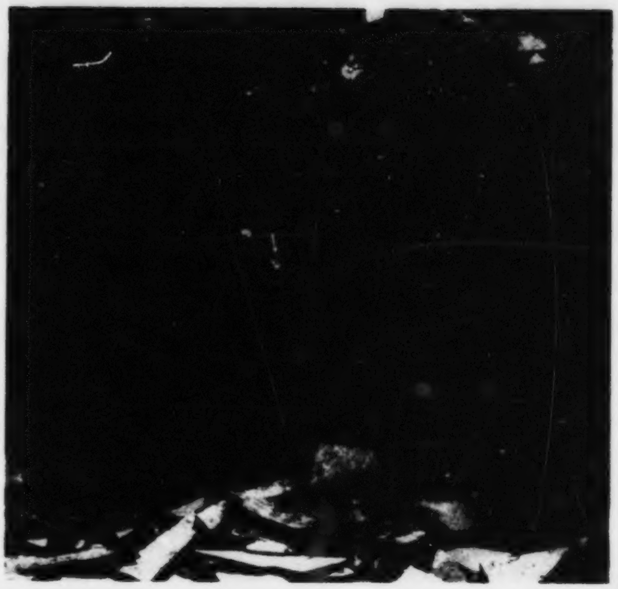


Photo O-7-1. EVENLY LAMINATED DOLOSTONE OF UNIT 1 BENEATH VUGGY DOLOSTONE OF UNIT 2; McCARTNEY QUARRY.

### REFERENCES

ARIP 119, 1985, p. 21

## O–8 OWEN SOUND LEDGEROCK LTD. — OWEN SOUND (CRUICKSHANK) QUARRY

### LOCATION AND OWNERSHIP

This quarry is located in Lot 17, Concession 4, Keppel Township, Grey County, approximately 8.6 km northwest of Owen Sound (Figure O–8–1). The quarry license covers 11.3 ha. The quarry is just west of Highway 70 on Ledgerock Road and is the site for much of Owen Sound Ledgerock's processing, marketing, and administration.

### GEOLOGY

This quarry exposes up to 3.2 m of the Eramosa Member of the Amabel Formation, which is subdivided into two units in this quarry. Quarrying has concentrated on the lowermost unit, a laminated dolostone, which is lithologically similar to the "Marble" beds of Eramosa Member quarries northwest of Wiarton (O–3, O–5 and O–6). The upper unit at this quarry is a thin–bedded, light brown dolostone, which is only present in thin patches in the southwest corner of the property. Stromatolitic beds pre-

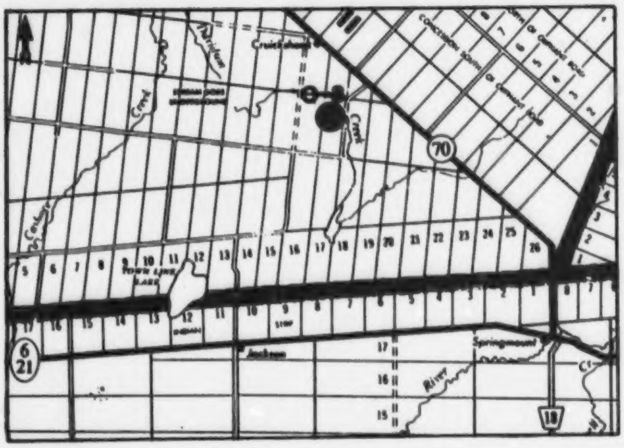


**Figure O-8-1. LOCATION MAP FOR OWEN SOUND (CRUICKSHANK) QUARRY.**

sent in the lower unit, below the quarry floor, are exposed in outcrop north of the quarry and in a small exploratory excavation (1 m deep) in the main quarry.

Two subparallel, linear anticlinal rolls, oriented 325° and 335°, trend through the centre of the quarry. Major vertical joints occur at 335 to 345° and 74 to 80° with spacings of 1 to 3 m. Glacial overburden thickness varies from less than 0.5 m to 1.5 m on the property.

### Geological Section

| | *Thickness* |
|---|---|
| *UNIT 2 Amabel Formation, Eramosa Member* | *0.3m* |
| Dolostone: light brown, weathers buff-brown; fine to medium crystalline; thin bedded; calcite infilling vugs; rare corals and crinoidal fragments, some small brachiopods; lower contact of unit is relatively sharp, but not well exposed. | |
| *UNIT 1 Amabel Formation, Eramosa Member* | *2.9m* |
| Dolostone: light grey to grey-brown, weathers light grey-brown; very fine to fine crystalline; laminated to thin bedded, with local wavy contacts, thin bituminous partings; local soft-sediment deformation structures. | |
| *Total thickness* | *3.2m* |

### QUARRY OPERATION

Quarry faces are about 1 m in height, and the quarry covers an area of about 7 ha. Quarrying is accomplished by a Darda hydraulic splitter using short vertical drill holes; less commonly by plug and feather, and portable diamond saws. Blocks are removed by bars and wedges, or by forklift.

### PROCESSING

Products are dressed by a variety of diamond saws and a guillotine. Three large diameter diamond saws, 1 m and 1.5 m in diameter, and about six smaller ones are used as well as an automatic marble polishing line. A Park Hydrasplit guillotine can accommodate slabs up to 125 cm in width by 30 cm in thickness, using a splitting pressure of 135 tonnes. Some stone from the Wiarton Quarry (O-5) is trucked to this location for dressing. It is interesting to note that random flagstone priced at $8 per ton in 1964 (Hewitt, 1964b, p. 11) was selling for $58 per ton in 1986.

### PRODUCTS

Cut and random flagstone
Sills
Mantels*
Wall Flag
Coursing Stone
Hearths*
Coping
Landscaping Stone
* Polished products prepared on request.

### REFERENCES

Hewitt, 1960, p. 125
Hewitt, 1964a, p. 58
Hewitt, 1964b, p. 10
Hewitt and Vos, 1972, p. 55
ARIP 119, 1985, p. 21

## O-9 E.C. KING CONTRACTING — TOLHURST QUARRY

### LOCATION AND OWNERSHIP

This quarry is located at the Tolhurst Farm, in Lot 37, Concession 2, Sarawak Township, Grey County, 14 km north of Owen Sound (Figure O-9-1). Licensed area of

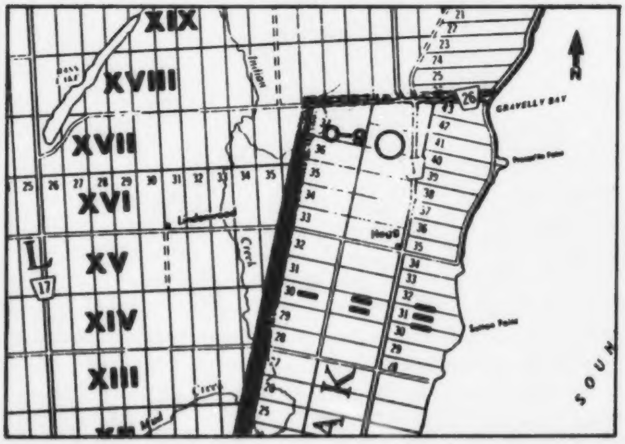


**Figure O-9-1. LOCATION MAP FOR TOLHURST QUARRY.**

the quarry is 33.4 ha. E. C. King Contracting produced crushed stone at this quarry during the summer of 1986.

### GEOLOGY

The Tolhurst Quarry exposes approximately 6 m of the Lower Silurian Manitoulin Formation. The lithology in this quarry varies from a light brown, thin-bedded dolostone in the uppermost metre down to a shaly green- to blue-grey, argillaceous, and slightly calcareous dolostone in the lower unit. The quarry was inactive and water-filled when visited, so information regarding its total depth and the depth of the unit contact was obtained from the operator.

### Geological Section

*Thickness*

*UNIT 2 Manitoulin Formation* *1.0m*

Dolostone: light brown; medium crystalline; thin bedded; chert as nodules and beds; calcite crystals fill vugs and occur as disseminated crystals; locally abundant fossil debris; lower contact appears gradational (below water level).

*UNIT 1 Manitoulin Formation* *5.0m*

Dolostone: green- to blue-grey; fine to medium crystalline; thin to medium bedded; slightly calcareous; argillaceous, with shaly partings; increasingly shaly with depth; locally fossiliferous beds with abundant shelly material; bioturbated; erosional scour surfaces throughout.

*Total thickness* *6.0m*

### REFERENCES

None

## O-10 E.C. KING CONTRACTING — SYDENHAM QUARRY

### LOCATION AND OWNERSHIP

E. C. King Contracting, a Division of Miller Paving Limited, is the operator of a dolostone quarry on Lot 25, Concession 2 South of Central Road, Sydenham Township, Grey County (Figure O-10-1). The company also owns parts of Lots 23 and 24, Concessions 1 and 2 (SCR). The property is 6.5 km east of Owen Sound and just south of Highway 26. The total licensed area is 101 ha.

### GEOLOGY

The single lift in this crushed stone quarry exposes up to 15 m of the Wiarton/Colpoy Bay Member of the Middle Silurian Amabel Formation. This member consists here of a single unit of light blue-grey, medium- to thick-bedded, fine- to medium-crystalline dolostone. A thin (6 m) zone at the top of the quarry section is rust-stained and fractured, probably due to surface weathering. Quaternary overburden thickness around the quarry is less than 1 m.

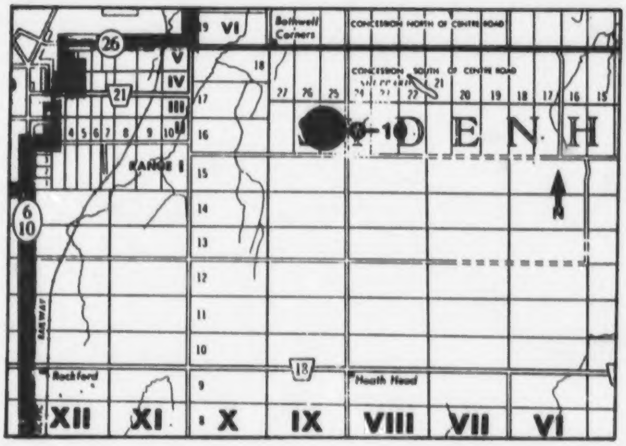


Figure O-10-1. LOCATION MAP FOR SYDENHAM QUARRY.

### Geological Section

*Thickness*

*UNIT 1 Amabel Formation, Wiarton/Colpoy Bay Member 15m*

Dolostone: white to light grey with blue-grey mottles, weathers light grey to tan-brown (directly beneath overburden); fine to medium crystalline; medium to thick bedded; blue-grey mottling varies in intensity, from 5 to 90%; calcite crystals fill vugs and fractures; vugs up to 5 cm in diameter occur scattered throughout and are sometimes concentrated in zones; fossiliferous with abundant crinoidal fragments and rare corals; upper 6 m is weathered to tan-brown colour, fractured, and thin bedded.

*Total thickness* *15m*

### QUARRY OPERATION

The quarry is operated on a single bench with a face height of 11 m to 15 m. Potential exists for an additional 6 m lower lift. Overburden is removed and used for making berms and ultimately for quarry reclamation.

The rock is drilled with a 10 cm rotary drill and blasted with aluminized AN/FO. Shot rock is loaded with a 5 1/2 yd. front end loader and transported to the feed hopper of the primary crusher.

### PROCESSING

A 36 in. x 46 in. Telsmith mobile jaw crusher with a reciprocating plate feeder is moved as required to maintain an economic haulage distance from the rock face. Minus 8 in. discharge from the primary crusher is conveyed to a surge bin feeding a 5 ft. x 18 ft. triple-deck vibrating screen.

Plus 4 in. oversize from the screen is either used as +4 in. −8 in. gabion stone or diverted to the secondary crusher. Undersize from the top screen can be a group 1 "B" gravel, or 1 1/2 in. clear and Granular "A". In the

**Photo O-10-1. MEDIUM- TO THICK-BEDDED WIARTON/COLPOY BAY MEMBER (AMABEL FORMATION). UPPERMOST 6 m IS THIN BEDDED AND FRACTURED; SYDENHAM QUARRY.**

latter case, the product from the second screen deck is diverted to the secondary crusher. Primary screen products are transported by belt and radial stacking conveyors to individual stockpiles.

The secondary crusher is a 4 1/4 ft. Allis–Chalmers cone, typically operated in open circuit. Secondary discharge is conveyed by belt to a 5 ft. x 16 ft. triple–deck vibrating screen producing 3/4 in. clear stone, 1/2 in. clear stone and class "D" screenings. Oversize from the top deck is diverted to a Spokane vertical impact tertiary crusher operated in closed circuit with the secondary screen.

Electrical power at the quarry site is generated by E. C. King with a 525 Kw diesel plant. All screens, belts, conveyors and the cone crusher receive power by buried ground cable.

The primary jaw crusher and the Spokane vertical impact crusher are powered by diesel engines.

### OWEN SOUND DOLOMITE PLANT

Screenings from the secondary screening plant, or 3/4 in. or 1/2 in. clear stone, are used to provide feed for the plant of Owen Sound Dolomite, a division of E. C. King Contracting. This plant produces glass grade dolomite, fertilizer diluent, agricultural lime and coarse mineral filler products and is located in Owen Sound near the plant of Pittsburgh Plate Glass, a large consumer of glass grade dolomite.

Stone from the Sydenham Quarry is trucked to the Owen Sound Dolomite plant for further processing. This stone is fed directly via a truck hopper to a gas–fired rotary drier, the dried stone being screened on two double–deck 4 ft. x 8 ft. hummer screens.

Top deck oversize from the hummer screens (+8 mesh) is diverted to a Hazemag A.P.K. 30 impact crusher in closed circuit with the hummer screens.

Product from the second deck can either be returned to the Hazemag crusher or be diverted to 5 ft. horizontal vibratory Sweco screens to produce -8 +12 mesh fertilizer grits.

Undersize from the hummer screens is -16 mesh and is further processed with an air classifier to produce a -16 +100 mesh glass grade dolomite and a fine fraction that is utilized as agricultural lime or coarse mineral filler.

Fertilizer grits are stored in a 5,000 ton capacity beehive storage dome, while glass grade and agricultural lime products are stored in individual silos. A small amount of coarse filler product is bagged. All other products are sold in bulk truck loads.

### PRODUCTS

Gabion Stone 4 in. -8 in.
Group 1 "B" Gravel
Granular "A"
1 1/2 in. Clear Stone
3/4 in. Clear Stone
1/2 in. Clear Stone
Screenings
Glass Grade Dolomite
Fertilizer Diluent
Agricultural Lime
Coarse Mineral Fillers

## HAROLD SUTHERLAND CONSTRUCTION LTD. QUARRY

At the time of field work and writing of the report, a quarry was being licensed by Harold Sutherland Construction Ltd. The quarry is located in Lot 5, Con. 5, St. Vincent Township, Grey County, about 5 km south of Meaford.

The quarry face varies from 1.5 m to 4.9 m. The upper part of the face exposes light brown, thin–bedded dolostone of the Lower Silurian Manitoulin Formation. In the lower 1.5 m to 3 m of the face, the Manitoulin Formation consists of blue–grey, fossiliferous massive dolostone. The contact between the Manitoulin Formation and the underlying Upper Ordovician Queenston Formation lies less than a metre under the quarry floor, and is exposed in a drainage ditch. Overburden at the quarry site is thin, but deepens to the west.

Prior to licencing, the quarry was operated temporarily under a wayside permit. While under permit, the quarry output was Granular "A" and "B" produced by a portable crusher. The products were being used for repair and maintenance of local roads.

# Simcoe District

## INTRODUCTION

The Simcoe District is located in the Southwestern Region of Southern Ontario, bounded by Lake Erie and the districts of Aylmer, Cambridge and Niagara. The District includes parts of Brant and Oxford Counties and the Regional Municipality of Haldimand–Norfolk (Figure S–0–1).

A total of twenty–nine quarries in the Simcoe District are documented in the quarry inventory (*see* Appendix IV, Volume I); three of these are licensed under the Pits and Quarries Control Act and only one, the Norfolk Quarry (S–2) is currently active.

The two quarries visited during the study were the active Norfolk Quarry (S–2) and the abandoned Pierce Quarry (S–1) which displays the Silurian/Devonian contact.

## REGIONAL GEOLOGY

The Simcoe District has relatively low relief with a southward–sloping plain; some hummocky morainic topography occurs in the northwest corner. A discontinuous ridge, the Onondaga Escarpment, crosses the northeastern part of the district through Hagersville and Springvale. Along the eastern margin of the area, the thickness of the Quaternary deposits averages less than 8 m, therefore bedrock exposures are relatively abundant along streams and the Lake Erie shoreline, although in 1986 most were obscured by high water levels. Several large, operating or abandoned quarries near Hagersville, Port Dover, and Nanticoke provide the best exposures for Paleozoic strata. West of Port Dover, Quaternary deposits average over 70 m in thickness and, therefore, no bedrock exposures occur and rock unit boundaries are based on subsurface data.

The oldest unit in this area, the Upper Silurian Salina Formation, does not outcrop, but is known from

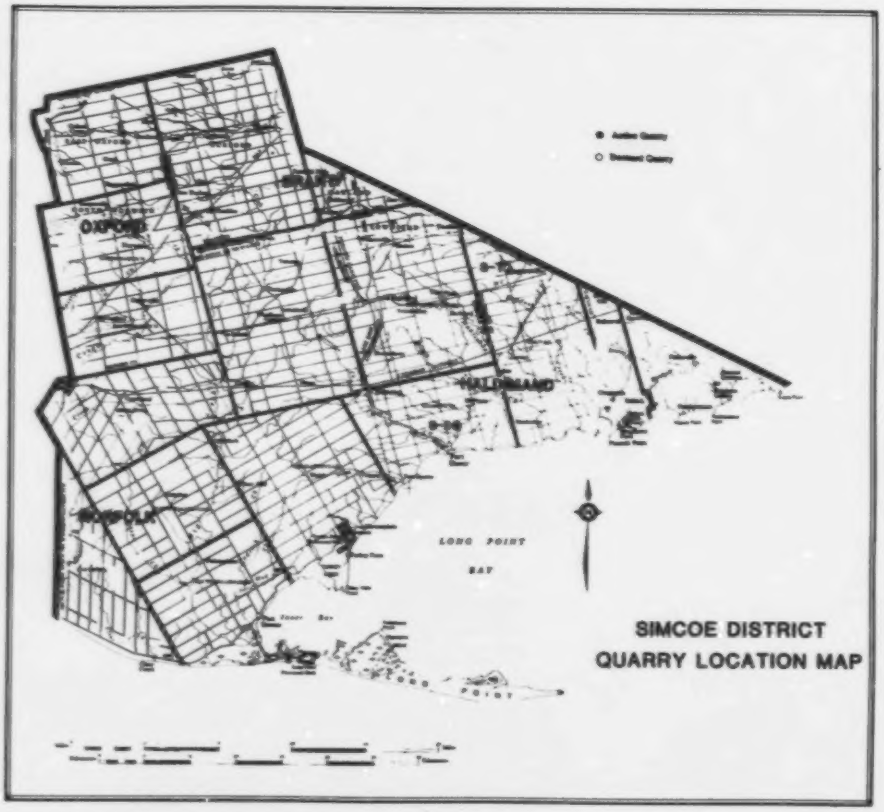
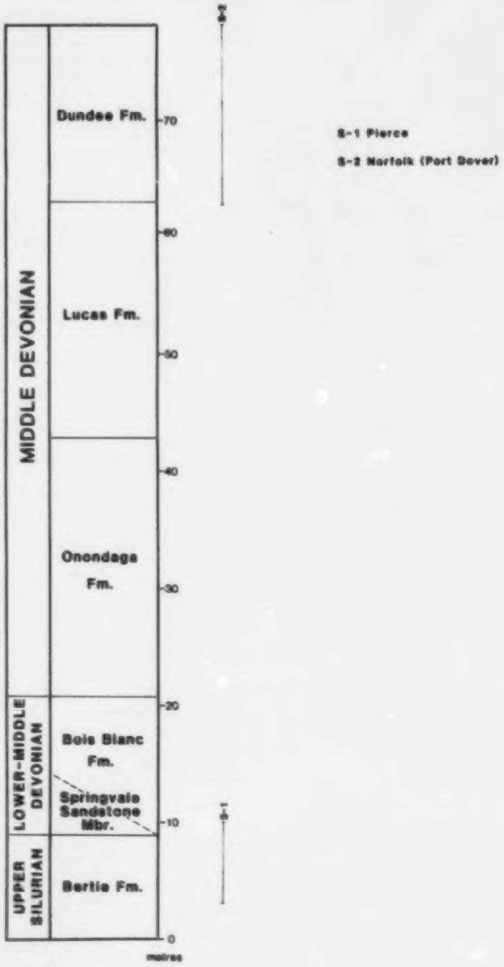


Figure S-0-1. SIMCOE DISTRICT QUARRY LOCATION MAP.



N.B. : Maximum thicknesses were assumed for this section

**Figure S-0-2. STRATIGRAPHIC COLUMN SHOWING PRINCIPAL QUARRIES OF SIMCOE DISTRICT.**

subsurface records. It consists of argillaceous dolostones, shales, and evaporites (predominantly gypsum). The overlying Upper Silurian Bertie Formation is well exposed in this district, especially around Hagersville and Springvale, but subdivision into members (as in southern Niagara District) is difficult to apply here. A variety of lithologies occurs in the lower 3.5 m of the Bertie Formation, which mainly include argillaceous dolostones and mottled dolostones. The upper 5 m consist of fine-crystalline, laminated dolostone. The upper contact of the formation is a major disconformity and its surface may be very pitted, brecciated and infilled with sand, chert or conglomeratic sediments, best seen in the Pierce Quarry (S-1). The resistant dolostones of the Bertie Formation form part of the Onondaga Escarpment.

The Lower Devonian Bois Blanc Formation, which overlies the Bertie Formation, occurs in the northeastern part of the district and is best seen in quarries around Hagersville. The Springvale Sandstone Member can occur at the base of the unit and consists of a green-grey, glauconitic, quartzose sandstone and limestone. The Bois Blanc Formation, aside from the Springvale Sandstone Member, is a cherty, fossiliferous, bioclastic limestone. The upper contact with the Onondaga Formation is sharp and disconformable.

The Middle Devonian Onondaga Formation is well exposed along the eastern margin of the district along Nanticoke, Sandusk, and Stoney Creeks and near the towns of Cheapside and Selkirk. The Edgecliff, Clarence and Moorehouse Members of the Onondaga Formation that could be easily identified in the Niagara District, are not so easily delineated in Simcoe District. All three members, however, can be seen in the extreme eastern corner along the Lake Erie shoreline and around Sweets Corners.

The Edgecliff Member (around Hagersville) consists of a very cherty, very fossiliferous, argillaceous limestone, interbedded with crinoidal bioclastic limestone. The middle part of the Onondaga (the Clarence Member), is best exposed along Nanticoke Creek near Rockford and Sandusk Creeks and consists of alternating beds of very fossiliferous, moderately cherty, bioclastic limestone and very cherty argillaceous limestone. The Moorehouse Member consists of a coralline bioclastic limestone with shale laminae.

The Onondaga Formation is restricted to the Appalachian Basin, and its presence in Simcoe District is its most westerly extension. Along the western edge of the district it grades into its approximate Michigan Basin equivalent, the Amherstburg Formation of the Detroit River Group. The Middle Devonian Lucas Formation (also Detroit River Group), overlies the Onondaga Formation and only extends eastward to the Town of Simcoe and then pinches out. The Lucas Formation consists of a uniformly textured, bioclastic limestone. This is the most easterly extension of this unit. Its upper contact with the overlying Dundee Formation is a major disconformity.

The Middle Devonian Dundee Formation forms much of the bedrock in the southern half of the district (Figure S-0-2). It is best seen in the Norfolk Quarry (S-2) and is a cherty, somewhat fossiliferous limestone. The lower portion contains two excellent marker beds (1.0 and 0.6 m thick), which consist of brown-black, very fine-crystalline, bituminous limestone (located 3.6 and 0.8 m, respectively, from the base), and are also best seen in the above mentioned quarry.

Only one quarry in this district, the Norfolk Quarry (S-2), is presently operating. The excavated rock material from the Dundee Formation in this quarry is used for crushed stone, chips and rock dust. There are twelve abandoned quarries in the Simcoe District which have utilized the Dundee Formation, whereas nine quarries have used the Bois Blanc Formation. Minor operations have also used the Onondaga and Bertie Formations.

### LIMESTONE INDUSTRIES

The single active quarry in Simcoe District produces limestone aggregates in various sizes from armour stone down to screenings.

Stone production in 1986 for the Regional Municipality of Haldimand–Norfolk totalled 1,234,960 tonnes, though by far the bulk of this production came from three quarries in Niagara District (NI–5, NI–8, NI–10), in the eastern part of Haldimand–Norfolk. Stone production in Simcoe District accounted for 10–15% of the total.

## S–1 C. MATTICE – PIERCE QUARRY

### LOCATION AND OWNERSHIP

This small abandoned quarry is located 0.5 km south of Springvale in Lot 7, Concession 14, City of Nanticoke (Walpole Township), Regional Municipality of Haldimand–Norfolk (Figure S–1–1). The quarry is owned by Chuck Mattice of Springvale.

### GEOLOGY

The quarry exposes 7.1 m of Upper Silurian and Lower Devonian strata from the Bertie and Bois Blanc Formations, respectively. The Bertie Formation consists mainly of subcrystalline to fine–crystalline dolostone, whereas the Bois Blanc Formation is represented by the Springvale Sandstone Member, a calcareous, glauconitic sandstone. Although this quarry ceased operating in 1950, it displays the Silurian/Devonian contact and therefore is included in this report.

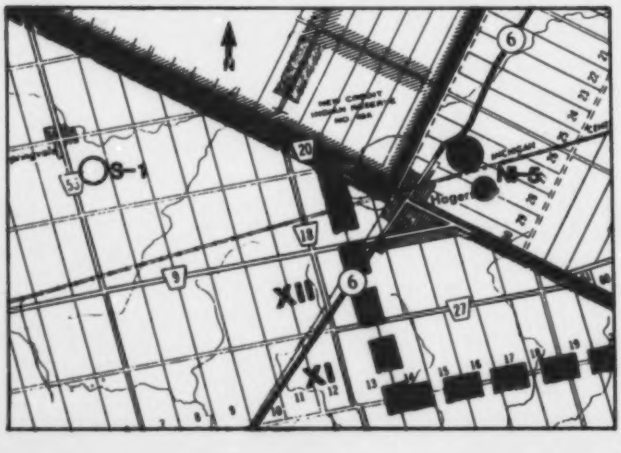


**Figure S-1-1. LOCATION MAP FOR PIERCE QUARRY.**

### Geological Section

*Thickness*

*UNIT 3 Bois Blanc Formation,*
*Springvale Sandstone Member* *1.6m*

Calcareous glauconitic sandstone: white to cream, weathers tan; coarse grained; medium bedded, beds are poorly delineated; the unit is a brecciated mixture of carbonates and silty glauconite in a matrix of coarse–grained sandstone; lower contact is transitional and irregular.

*UNIT 2 Bertie Formation* *1.7m*

Dolostone: cream to white, weathers brown; subcrystalline to fine crystalline; medium bedded with sharp contacts which are irregular and pinch and swell; shaly partings occur throughout; lower contact is sharp at a 5 cm thick shale bed.

*UNIT 1 Bertie Formation* *3.8m*

Dolostone: cream to white, weathers brown; sub– to fine crystalline; thin to medium bedded (less than 30 cm), gets thinner bedded upwards, contacts are sharp and undulating; slightly sucrosic; faint grey laminations present; thin bituminous partings present.

*Total thickness* *7.1m*

### REFERENCES

ARIP 59, 1984, p. 20

### MAPS

Telford and Hamblin, 1980, OGS Map P.2234

## S–2 NORFOLK QUARRIES COMPANY – NORFOLK (PORT DOVER) QUARRY

### LOCATION AND OWNERSHIP

The Norfolk Quarry is located 4 km northeast of the town of Port Dover on Regional Rd. 3, in Lots 13 and 14, City of Nanticoke (Woodhouse Township), Concession 2, Regional Municipality of Haldimand–Norfolk (Figure S–2–1).

The quarry was first opened in 1963 by the present owner and operator, Norfolk Quarries Company, which is itself owned by Trent Valley Sand and Stone Ltd.

### GEOLOGY

This unusually–shaped quarry extends sinuously along a stream valley exposing 15 m of section through the lower Dundee Formation (Middle Devonian) (Figure S–2–2). The strata in the quarry are typically cherty, fossiliferous limestone with chert occurring in discrete, thin beds. A bituminous limestone bed which contains large colonial corals occurs approximately 3.5 m above the base of the quarry face. The rarely exposed contact between the Onondaga and Dundee Formations was, at one time, exposed in a sump at the eastern end of the quarry.

## Geological Section

*Thickness*

*UNIT 5 Dundee Formation* *10.53m*

Limestone: light brown, weathers grey; fine crystalline, (coarse where shelly material occurs); massive bedded at base, becomes medium bedded at the top, with sharp, irregular stylolitic contacts and bituminous partings; the unit becomes cherty upwards which occur as nodules and beds – the chert is cream in colour and some nodules have black centres; brachiopod and crinoid debris are abundant, along with rare coral the lower contact is sharp.

*UNIT 4 Dundee Formation* *0.90m*

Shaly limestone, argillaceous: dark brown, weathers brown; very fine to fine crystalline; thin bedded, contacts are sharp and planar, bituminous partings are common; chert is present as nodules and lenses, calcite crystals occur in fractures; some sedimentary features are present such as flame structures and scouring, sparsely fossiliferous with rare bryozoans; lower contact is sharp.

*UNIT 3 Dundee Formation* *0.45m*

Limestone: brown, weathers light brown; medium to coarse crystalline; medium bedded, with undulating contacts and rare bituminous partings; chert is present as lenses and nodules; lower contact is sharp.

*UNIT 2 Dundee Formation* *0.90m*

Bituminous limestone: grey-brown, weathers light grey; fine to medium crystalline; sucrosic texture; one massive bed; porous coral heads are abundant, solitary corals are rare; fractures are abundant (in all directions); lower contact is sharp and undulating.

*UNIT 1 Dundee Formation* *2.21m*

Cherty limestone: dark brown, weathers dark grey-brown; fine crystalline, sucrosic texture; thin to medium bedded, contacts are sharp but irregular; rare argillaceous zones; cream coloured chert occurs as nodules and as irregular thin lenses, black chert occurs in middle of unit; calcite mineralization is present along fracture faces; abundant coral heads and rugose corals present.

*Total thickness* *14.99m*

## CHEMICAL ANALYSIS - GRANULAR "A"*

| | | | |
|---|---|---|---|
| $SiO_2$ | 22.0 | CaO | 39.5 |
| $Al_2O_3$ | 0.50 | $P_2O_5$ | 0.02 |
| $Fe_2O_3$ | 0.34 | $SO_3$ | 0.28 |
| MgO | 3.20 | L.O.I. | 34.5 |
| | | Total | 100.3 |

* *Sample from crushed stone stockpile reported in Hewitt and Vos, 1972, p.70.*

## QUARRY OPERATION

The quarry extends approximately 1,200 m in length and 60 m in width along the course of an old riverbed exposing bedrock on the surface. A limit of about 3 m to 4.6 m of overburden is removed on either side of the quarry though as much as 14 m exists.

The quarry has been excavated on two lifts of 9.1 m each. Drilling and blasting is contracted, a 2.9 m x 2.9 m pattern being used with 8.9 cm diameter holes. Holes are

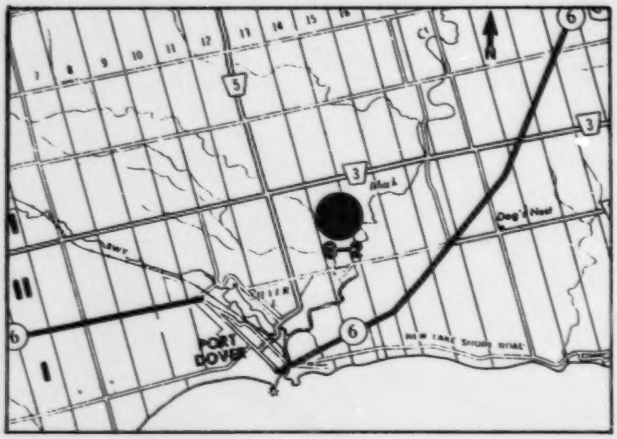


Figure S-2-1. LOCATION MAP FOR NORFOLK (PORT DOVER) QUARRY.

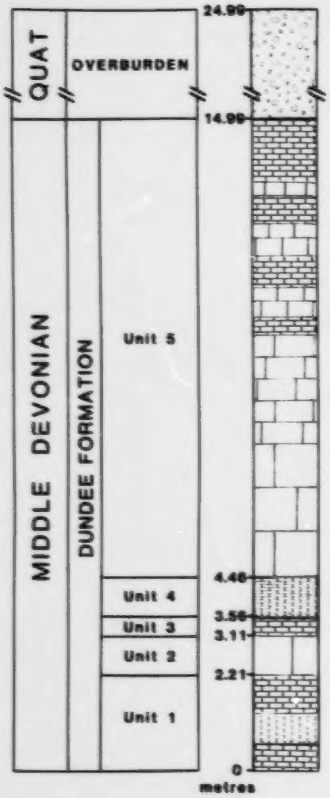


Figure S-2-2. STRATIGRAPHIC COLUMN FOR NORFOLK (PORT DOVER) QUARRY.

Photo S-2-1. NORFOLK (PORT DOVER) QUARRY FACE (LOOKING NORTHWEST).

loaded with AN/FO, primed with a slurry cartridge and initiated with electric caps. At the face a 1.5 yd. Linkbelt shovel loads the blasted rock into two 22-ton Euclid trucks.

Ground water in the quarry is controlled using a 6 in. Flygt pump.

## PROCESSING

Primary crushing is by Cedarapids 40 in. x 40 in. double impact crusher. The crushed stone is screened by a 2-deck 5 ft. x 14 ft. screen. Secondary crushing of the oversize is handled by a Symons short head cone crusher in closed circuit with the 5 ft. x 14 ft. screen. The end products are conveyed approximately 900 m to a Barber-Greene 150 ft. stacker or to a specialty products triple-deck 5 ft. x 14 ft. tertiary screening plant as per customer requirements.

## PRODUCTS

Armour Stone
Granular "A" and "B"
2 in. Crusher Run
4 in. Crusher Run
3/4 in. Clear
2 in. Clear
Screenings
3/8 in. Chips
Additional size fractions are available on request.

## REFERENCES

Hewitt and Vos, 1972, p. 69-70

Hewitt, 1964a, p. 66-67

Telford and Johnson, 1984 GAC-MAC Field Trip 1, p. 28

ARIP 59, 1984, p. 20

## MAPS

Telford and Hamblin, 1980, OGS Map P.2234

Photo S-2-2. EUCLID TRUCK LOADING CEDARAPIDS PRIMARY CRUSHER AT NORFOLK (PORT DOVER) QUARRY.

# Aylmer District

## INTRODUCTION

Aylmer District is centrally located in the Southwestern Region of southern Ontario, bounded by Lake Erie to the south and the districts of Chatham, Wingham and Simcoe to the west, north and east, respectively (Figure A–0–1).

Four active quarries in the district are documented in the quarry inventory (*see* Appendix IV, Volume I), all of which were visited during the study. A separate cement plant that receives its feed from one of the quarries is also noted.

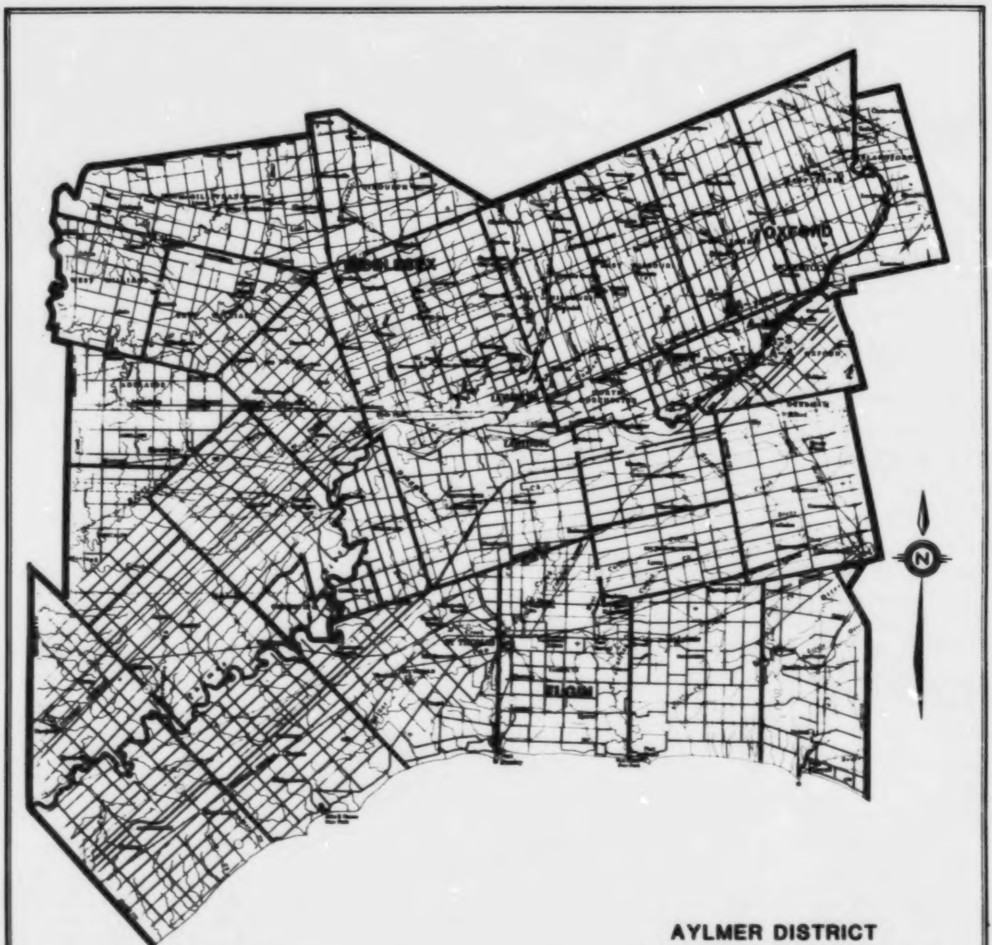


**Figure A–0–1. AYLMER DISTRICT QUARRY LOCATION MAP.**

The properties include:

| | |
|---|---|
| *A–1* | *Lafarge Canada Inc. – Woodstock (Zorra) Quarry and Plant (active)* |
| *A–2* | *BeachviLime Ltd. Quarry and East Plant (active)* |
| *A–3* | *BeachviLime Ltd. Quarry and West Plant (active)* |
| *A–4* | *Stelco Inc. Quarry and Plant (active)* |
| *A–5* | *Federal White Cement Ltd. – Woodstock Plant (active)* |

## REGIONAL GEOLOGY

The main geomorphic feature in Aylmer District is the Thames River. The Algonquin Arch, a major bedrock structure, is present in the subsurface and trends southwest to northeast through the district. Natural bedrock exposures are non–existent in this district due to the thick Quaternary cover, the only exposures being provided by four large operating quarries in the Ingersoll to Woodstock area.

The Middle Devonian Amherstburg and Lucas formations of the Detroit River Group are exposed within quarries in the district and represent the transition from Appalachian Basin rock units found on the Niagara Peninsula to Michigan Basin rock units seen west of the Algonquin Arch (Figure A–0–2). The lateral relationships of these Paleozoic rock units are not clear in this area due to the absence of outcrop and minimal subsurface data.

The oldest stratigraphic unit subcropping in the district is the Upper Silurian Bass Islands Formation (dolostone). It is disconformably overlain by the Lower Devonian Bois Blanc Formation, a cherty limestone, which is in turn overlain by the exposed Detroit River Group (Middle Devonian). Overlying this are the following, unexposed, units (all Middle Devonian and in ascending stratigraphic order); the Dundee Formation (limestone); the Marcellus Formation (grey shale) and the Hamilton Group (grey shales and limestones).

The Amherstburg Formation is predominantly a cherty limestone with abundant bituminous partings and abundant stromatoporoids. It is presently only being extracted from the lower lifts of the Woodstock (Zorra) Quarry (A–1).

The Lucas Formation is represented in all four operating quarries and consists predominantly of a high purity limestone interbedded with brown to tan bioclastic limestones, microcrystalline limestones, and calcarenites. Bituminous partings and large football–shaped stromatoporoids can be abundant. The high purity portion of the Lucas Formation is referred to as the Anderdon Member in the Ingersoll area. The uppermost portion of the Anderdon Member in the Stelco Quarry (A–4) exposes a 5 m section of sandy limestone, a massive bedded, brown, silty and fossiliferous unit. This sandy facies is found only in the Ingersoll and Amherstburg (Chatham District) area.

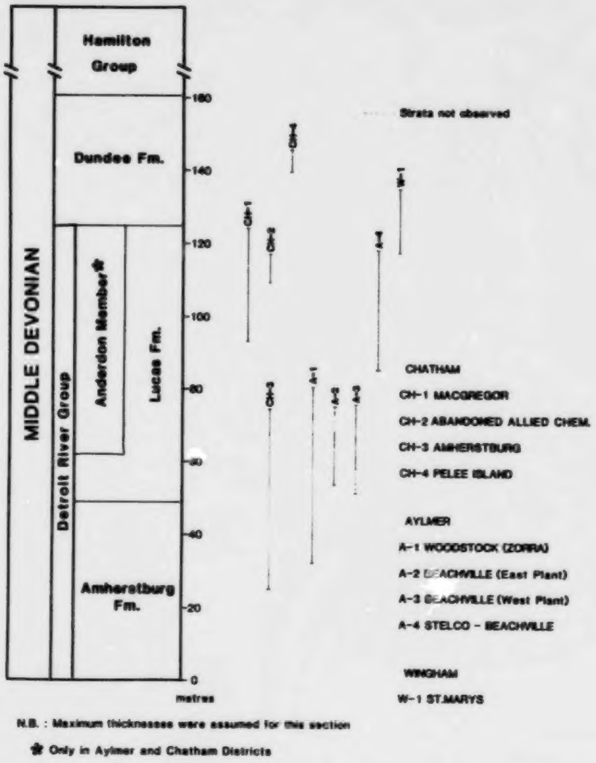

MIDDLE DEVONIAN
Detroit River Group
Hamilton Group
Dundee Fm.
Anderdon Member*
Lucas Fm.
Amherstburg Fm.
160
140
120
100
80
60
40
20
0
metres
CH-1
CH-2
CH-3
CH-4
A-1
A-2
A-3
A-4
W-1
Strata not observed
CHATHAM
CH-1 MACGREGOR
CH-2 ABANDONED ALLIED CHEM.
CH-3 AMHERSTBURG
CH-4 PELEE ISLAND
AYLMER
A-1 WOODSTOCK (ZORRA)
A-2 BEACHVILLE (East Plant)
A-3 BEACHVILLE (West Plant)
A-4 STELCO - BEACHVILLE
WINGHAM
W-1 ST.MARYS
N.B. : Maximum thicknesses were assumed for this section
* Only in Aylmer and Chatham Districts

Figure A–0–2. STRATIGRAPHIC COLUMN SHOWING PRINCIPAL QUARRIES OF AYLMER, CHATHAM AND WINGHAM DISTRICTS.

BeachviLime Ltd., (A–2 and A–3), extracts high purity limestone from the Amherstburg and Lucas formations (Anderdon Member).

## LIMESTONE INDUSTRIES

The principal limestone industries in Aylmer District are cement and lime production, with minor amounts of granular limestone. All the producing quarries (A–1, A–2, A–3 and A–4) and the Federal White Cement Plant (A–5) are located in Oxford County.

Cement production in 1986 totalled approximately 494,000 tonnes (1987 Ontario Mineral Score), principally from the Lafarge Canada Inc. plant (A–1). Lafarge Canada Inc. markets a wide variety of products including, but not restricted to, Normal Portland, High Early Strength Portland, Sulfate Resisting Portland, Low Heat of Hydration Portland and Masonry Cement.

The high purity limestone extracted from the Lucas Formation is also used for the manufacture of high calcium lime, some of which is used as metallurgical flux for the steel industry in Hamilton. The sandy limestone facies of the Anderdon Member (Lucas Formation) was formerly considered a waste rock by the operator of the Stelco Quarry (A–4), though a market has now been found for this material. The 1986 production of lime in Aylmer District totalled some 690,000 tonnes (1987 Ontario Mineral Score).

Stone production in 1986 totalled 2,584,000 tonnes (1987 Ontario Mineral Score), almost all of which was internally consumed by the cement and lime plants. The BeachviLime East plant (A–2) also produces dried granular limestone for use in agriculture, animal feed, glass and roofing shingle industries.

## A–1 LAFARGE CANADA INC. – WOODSTOCK (ZORRA) QUARRY AND PLANT

### LOCATION AND OWNERSHIP

Lafarge Canada Inc. operates a large quarry and a 500,000 tonne per year wet process cement plant in Lots 2 to 5, Concession 2 and 3 and Lots 1 to 3, Concession 4, Township of Zorra (West Zorra Township), Oxford County. The quarry and plant are located approximately 23 km west of Woodstock on Highway 2 at County Road #6, as shown in Figure A–1–1. A line of the Canadian Pacific Railway runs through the property.

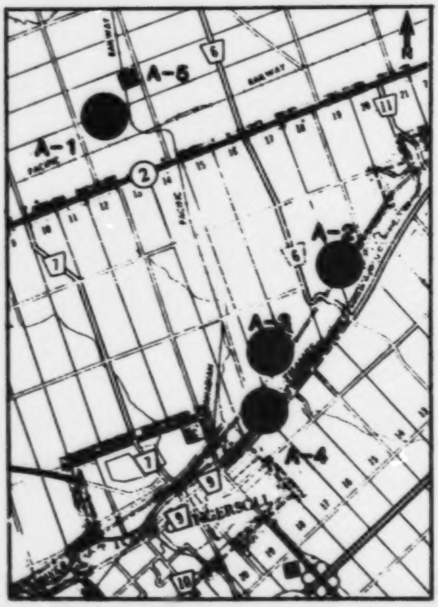

A-5
A-1
A-3
A-2
A-4
2
6
7
9
11
19
RAILWAY
PACIFIC
INGERSOLL

Figure A-1-1. LOCATION MAP FOR WOODSTOCK (ZORRA) QUARRY.

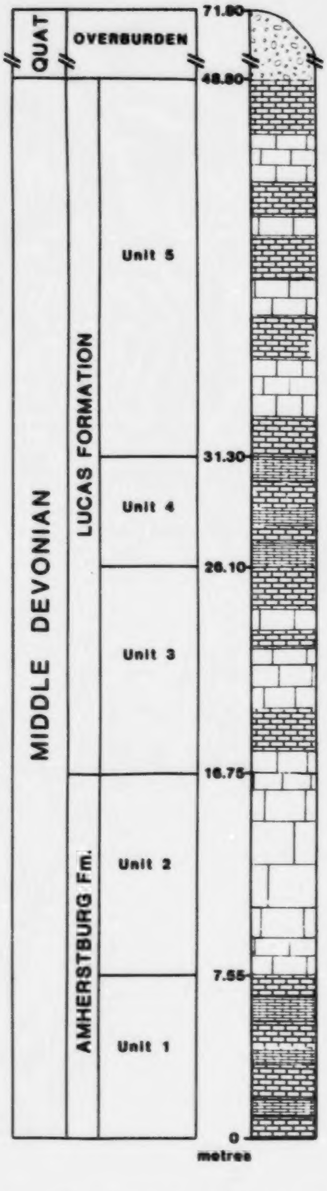

QUAT
OVERBURDEN
MIDDLE DEVONIAN
LUCAS FORMATION
AMHERSTBURG Fm.
Unit 5
Unit 4
Unit 3
Unit 2
Unit 1
71.80
48.80
31.30
26.10
16.75
7.55
0
metres

Figure A-1-2. STRATIGRAPHIC COLUMN FOR WOODSTOCK (ZORRA) QUARRY.

### GEOLOGY

A total of four lifts expose a 48.8 m section from the Middle Devonian Detroit River Group (Figure A–1–2). The two lower lifts expose 16.75 m of the Amherstburg Formation, a cherty, banded and fossiliferous limestone. Silica content tends to increase down the section and

Lafarge Canada Inc. is deepening the quarry to take advantage of this silica-rich limestone. A very prominent stromatoporoid zone occurs within the second lift.

The upper lifts expose a 32.05 m section of the Lucas Formation, a bioclastic and microcrystalline (lithographic) limestone. There is a well-defined contact with the underlying Amherstburg Formation.

## Geological Section

*Thickness*

*UNIT 5 Lucas Formation* *17.5m*

Limestone: brown to tan, weathers tan; sub to very fine crystalline; medium to thick bedded (up to 1 m), contacts are sharp, slightly irregular with thin bituminous partings; upper 5.65 m is thin to medium bedded, lithographic texture; with calcite present in vugs; coralgal debris and large stromatoporoids (up to 1 m) scattered about; beds vary slightly in colour throughout; lower contact is top of lift #2.

*UNIT 4 Lucas Formation* *5.2m*

Limestone: tan to light brown, weathers buff; subcrystalline; thin to medium bedded (3 to 30 cm), contacts are sharp, irregular, and some are slightly stylolitic and bituminous; lithographic texture; calcite mineralization in small pores and replaces fossils and burrows; fossils are recrystallized; gradational lower contact (colour change).

*UNIT 3 Lucas Formation* *9.35m*

Interbedded bioclastic limestone and non-fossiliferous limestone: light brown to tan, weathers tan to buff; bioclastic limestone is fine crystalline; non-fossiliferous limestone is micro- to subcrystalline; medium to thick bedded (up to 80 cm), contacts are fairly sharp, some are stylolitic and bituminous; lithographic texture; bituminous partings are not as abundant as unit above; laminations are only present in bioclastic limestones; fossils include very abundant coralgal debris and rare brachiopods and bryozoans, scattered burrows are present on bedding planes; lower contact is sharp, irregular and is mainly a colour change.

*UNIT 2 Amherstburg Formation* *9.2m*

Cherty limestone: dark brown to tan, weathers light to medium grey; fine to medium crystalline; thick to massive bedded (up to 1.5 m), contacts are not sharp, but are irregular and have bituminous partings; chert is blue-white (about 30%) and nodular shaped; upper 1.15 m are more thinly bedded and weathers rubbly, and chert nodules are smaller; abundant large stomatoporoids (up to 1 m in diameter) occur throughout, some coralgal debris present, with rare bryozoans and brachiopods; lower contact is gradational.

*UNIT 1 Amherstburg Formation* *7.55m*

Cherty limestone: medium grey to tan, weathers grey-brown; medium to coarse crystalline; thin to medium bedded (3 to 30 cm), contacts are sharp and very irregular; chert (about 40%) is mainly black with white rims, occurs as very irregular nodules or beds; beds have laminations; some chert replaces burrows and fossils; rare lenses of interbedded subcrystalline limestones (lithographic texture); very abundant thin bituminous laminae with a strong petroliferous odor; rare calcite in large vugs (3 to 4 cm); solitary corals are abundant (some are up to 35 cm long).

*Total thickness* *48.8m*

Chemical analyses of drill core from a typical hole, No. 17, drilled by Lafarge Canada Inc., are presented in Table A-1-1.

Typical bench analyses as reported by Lafarge Canada Inc. are tabulated in Table A-1-2.

The stone in the quarry is very consistent in its chemical analysis within each bench. Working the 4th (bottom) bench will allow the plant to obtain a high silica stone and provide for a natural cement mix. Overburden in the pit area is thick, averaging over 23 m, and is removed by means of stripping operations involving scrappers, trucks, and bulldozers.

## QUARRY OPERATION

The present quarry occupies a surface area of approximately 65 ha. Three benches are currently being worked, with a fourth bench being developed. Bench heights are 18 m, 12 m, 20 m and 15 m respectively.

Drilling and blasting are performed under contract using a 171 mm rotary percussion drill on a 6 m x 6 m pattern. Nordex is used as the explosive. Shot rock is loaded by two 7 yd. Caterpillar front-end loaders into three dump trucks of 30-50 ton capacity. The average haul distance to the primary crushers is 1.2 km.

**TABLE A-1-1. A-1 LAFARGE CANADA INC. WOODSTOCK (ZORRA) QUARRY.**

| | Composite Bench Analyses - Hole 17 | | |
|---|---|---|---|
| **Elements** | **Bench 1 + 2** | **Bench 3** | **Bench 4** |
| CaO | 54.87% | 47.34% | 27.25% |
| $SiO_2$ | 0.48% | 7.15% | 40.71% |
| $Al_2O_3$ | 0.05% | 0.29% | 1.22% |
| $Fe_2O_3$ | 0.09% | 0.15% | 0.45% |
| MgO | 0.98% | 4.33% | 4.20% |
| $K_2O$ | 0.01% | 0.06% | 0.53% |
| $Na_2O$ | 0.01% | 0.01% | 0.02% |

*Courtesy of Lafarge Canada Inc. - Company Files.*

**TABLE A-1-2. A-1 LAFARGE CANADA INC. WOODSTOCK (ZORRA) QUARRY.**

| | Typical Composite Bench Analyses | | |
|---|---|---|---|
| **Elements** | **Bench 1 + 2** | **Bench 3** | **Bench 4** |
| CaO | 53.0% | 48.0% | 23.5% - 43.0% |
| $SiO_2$ | 1.0% | 4.0% | 10.3% - 45.6% |
| $Al_2O_3$ | 0.4% | 0.4% | 0.2% - 1.6% |
| $Fe_2O_3$ | 0.3% | 0.3% | 0.1% - 0.6% |
| MgO | -- | 2.7% | 2.75% - 5.83% |
| $K_2O$ | -- | 0.1% | 0.04% - 0.3% |
| $Na_2O$ | -- | 0.1% | 0.01% - 0.016% |

*Courtesy of Lafarge Canada Inc. - Company Files.*

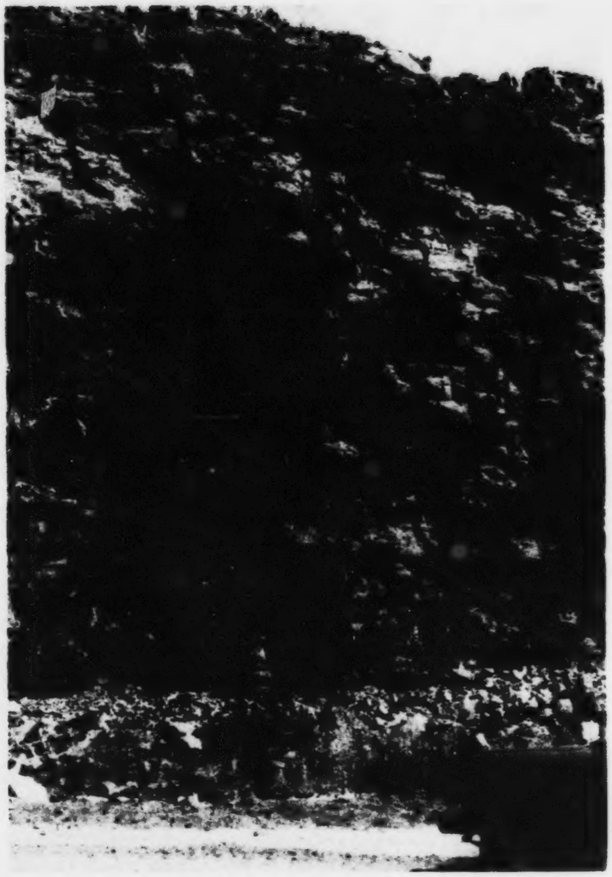


Photo A-1-1. LUCAS FORMATION, UNIT 1 EXPOSED IN THE FIRST LIFT; WOODSTOCK (ZORRA) QUARRY.

### PROCESSING

Primary crushing is carried out with a Traylor T 54 in. gyratory crusher. Minus 6 in. material is carried by a 42 in. underground belt conveyor to a secondary CB 15–50 impact crusher, operating in closed circuit with screens to reduce the material to –3/4 in.. Belt conveyors move the stone to raw material storage at the plant (30,000 tonnes capacity).

Gypsum–anhydrite is stored in open piles near the mill feed storage adjacent to the finish mill. Gypsum–anhydrite is supplied by Canadian Gypsum Company.

Crushed stone (from the various benches), fly ash, and iron oxide mill scale are recovered from raw mill storage area by a 5 yd. bucket overhead crane and pan conveyors for blending and feeding to the raw mills.

The raw mill consists of three 2–compartment Unidan ball mills. The raw mix is ground to 90% passing 200 mesh and pumped to blending basins as 32% moisture. The two 33.5 m diameter blending basins are equipped with rotating and air agitation systems.

The blended mill feed slurry (30% solids) is pumped to two F.L. Smidth coal/coke fired kilns (convertible to natural gas or oil), that are each 12 ft. x 450 ft. in size. Refuse (municipal garbage) derived fuel (RDF), blended with coal or another fuel substitute, has been successfully experimented with in the past, but for various reasons, is not currently in use. The kilns are fitted with electrostatic precipitators to control dust.

Clinker is cooled in two 7 ft. x 44 ft. Fuller inclined grate systems and passed through an impact crusher prior to transfer by pan conveyor to storage. Clinker storage is approximately 20,000 tonnes.

Clinker is recovered from storage by belt conveyors and fed to a series of F.L. Smidth ball mills. A 40/60 anhydrite/gypsum mixture is added to the clinker at a rate of approximately 5%. The ball mills range in size from a 4,000 hp 24 ft. x 36 ft., 70 tons per hour unit to six 1,100 hp 9 ft. x 24 ft. units. Finished cement is pneumatically conveyed to storage silos for loading into rail cars, tanker trucks and bags.

### PRODUCTS

Normal Portland Cement
High Early Strength Portland Cement
Sulfate Resisting Portland Cement
Low Alkali Cement
Masonry Cement
Oil Well Cement

### REFERENCES

Hewitt, 1960, p. 158–161
Hewitt, 1964a, p.65
Blair, 1965, p.52–54
Hewitt and Vos, 1972, p.67–68
Telford and Johnson, 1984, p.29–31

## A–2 BEACHVILIME LTD. QUARRY AND EAST PLANT

### LOCATION AND OWNERSHIP

The East plant of BeachviLime Ltd. is located southwest of Beachville in Lots 17 and 18, Concessions 1 and 2, Township of Zorra (North Oxford Township), Oxford County (Figure A–2–1). The quarry and plant, formerly owned by Domtar, form a fully integrated production facility for hydrated lime, pulverized lime, pebble lime and granular limestone. In 1929 the Gypsum, Lime and Alabastine Co. purchased three quarries and two lime plants from Standard White Lime Co. The entire operation was consolidated and purchased in 1959 by Domtar. BeachviLime Ltd. purchased the operation in 1984.

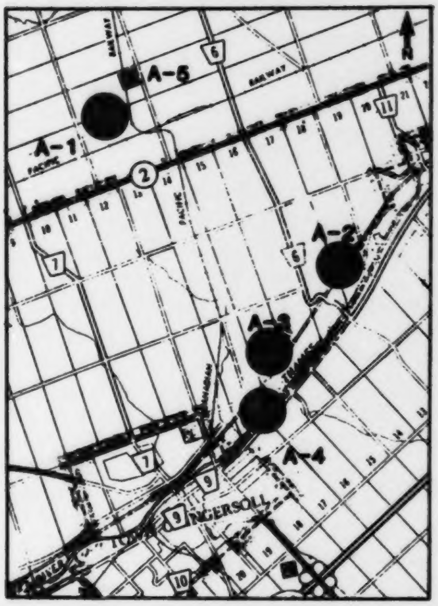


Figure A-2-1. LOCATION MAP FOR BEACHVILIME PLANT #2.

## GEOLOGY

The quarry exposes 20 m of the Middle Devonian Lucas Formation (Anderdon Member), which consists of bioclastic limestones, interbedded microcrystalline limestones, and calcarenites. Distinctive large, football-shaped stromatoporoids occur at various horizons. The geological section is very similar to that in quarry A-3, immediately to the southwest, where it is described in more detail. Overburden is about 23 m thick.

## QUARRY OPERATION

Quarry operations for the East plant are now located north of the C.N. Railway line and are connected by a tunnel to the processing plants in the abandoned south quarry. High purity limestone is mined from a single 20 m bench. Overburden is removed by a contractor and the rock surface is washed clean prior to drilling.

Production drilling is with a 159 mm percussion drill, on a hole spacing of 6 m x 6 m to 5% below grade.

Drill holes are pumped dry before loading with hydromex and AN/FO explosives, the latter being mixed on site by supplier's equipment. A single row of holes is blasted in each shot, providing 11,000 to 22,000 tons of broken rock.

The blasting sequence is designed to achieve a fine break and is geared to loader and crusher capability. Oversize rock is sorted out and secondary breaking is by drop-ball. The final quarry floor is level and smooth.

Broken stone is loaded by 6.5 yd. front-end loaders equipped with "spade nose" buckets into four 16.5-ton side-dump trailers and hauled by Mack diesel tractors. The size of haulage equipment is restricted by the size of the tunnel connecting the quarry with the plant facilities.

## PROCESSING

Primary crushing is by a 30 in. Allis-Chalmers gyratory crusher, installed level with the quarry floor. This crusher has no dump pocket feeder or grizzly, and the rock is dumped directly into the crusher via a hook and cable system controlled by the crusher operator.

The secondary crusher is a 40 in. Nordberg Symons shorthead cone which reduces the stone to -4 in. and discharges it through a grizzly with 5 1/2 in. square openings.

Secondary crushed rock is transported by return belt and transfer conveyor to a stockpile located over a single drawpoint. Crushed rock is then recovered from beneath the stockpile with a Syntron feeder and carried on a 35 in. x 377 ft. inclined conveyor belt to the screenhouse, located on top of seven large, flat-bottom concrete silos. Crushed rock is screened in three stages on double-deck inclined vibratory screens located above the silos; seven product sizes are produced.

The first screen is a 5 ft. x 16 ft. Symons vibrating screen equipped with 4 in. and 2 1/4 in. screen decks, which yield -6 in. + 4 in. and -4 in. + 2 1/4 in. products.

The -2 1/4 in. undersize is conveyed by belt to a secondary 5 ft. x 16 ft. Tyler screen, equipped with 1 1/4 in. and 7/8 in. screen decks, that yield -2 1/4 in. + 1 1/4 in. and -1 1/4 in. + 7/8 in. products.

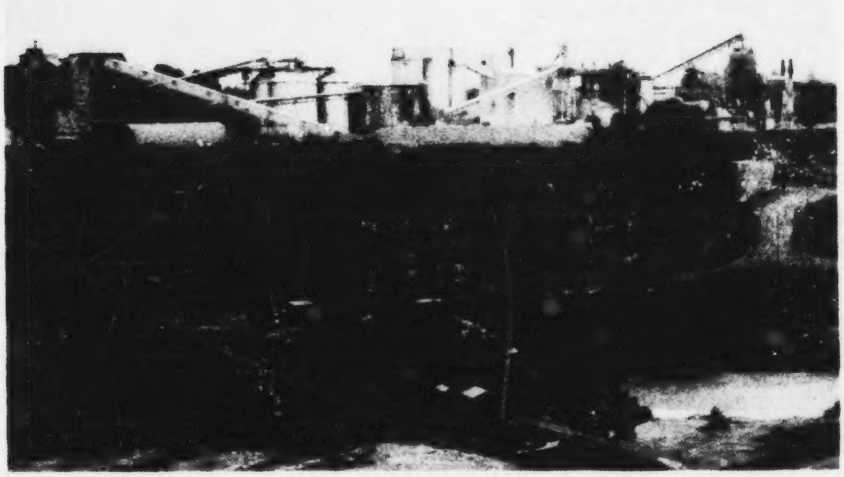
The -7/8 in. undersize material from this stage is conveyed by belt to a tertiary 5 ft. x 16 ft. Symons vibratory screen, equipped with 1/2 in. and 1/4 in. screen decks, and these produce -7/8 in. + 1/2 in., -1/2 in. + 1/4 in. and -1/4 in. stone.

The seven product sizes discharge directly into seven large, flat bottom concrete storage silos of the following capacity:

| Silo # | Capacity (tons) | Live/Capacity (tons) | Product |
|---|---|---|---|
| 1 | 1,000 | 700 | -1/4 in. |
| 2 | 1,000 | 700 | +1/4 in. - 1/2 in. |
| 3 | 1,000 | 700 | +1/2 in. - 7/8 in. |
| 4 | 1,000 | 700 | +7/8 in. - 1 1/4 in. |
| 5 | 1,500 | 700 | +1 1/4 in. - 2 1/4 in. |
| 6 | 1,500 | 700 | +2 1/4 inc. - 4 in. |
| 7 | 1,500 | 700 | +4 in. - 6 in. |

Stone products are withdrawn from storage silos via bottom discharge feeders and conveyor belts. The large (+4 in. - 6 in.) stone is used as feed for the shaft kilns and +2 1/4 in. -4 in. stone is used as feed for the dried

Photo A-2-1.
BEACHVILIME LIMITED -
EAST PLANT.



stone plant or is recrushed for blast furnace stone. All other products (except −1/4 in.) are used as feed for the rotary kilns.

### Lime Plant

Kiln stone is fed to a scalping screen to remove additional fines before it is transferred by overhead conveyor to three kiln feed silos. Kilns #1 and #2 have 100–ton feed silos, while kiln #3 has a 200–ton feed silo.

The plant is equipped with three rotary kilns with a combined capacity of 1,180 tons of lime per day. Two of the kilns are 249 ft. x 9 ft. Allis–Chalmers units equipped with quadrant heat exchangers and 3 ft. x 49 ft. reciprocating coolers. These kilns can be fired with a combination of natural gas and petroleum coke or with low sulphur coal.

The third rotary kiln is a 320 ft. x 11 ft. GATX–Fuller unit with a Neims cooler. The #3 kiln is fired with preheated bunker C oil or natural gas.

### Lime Handling and Storage

Lime produced by any of the kilns can be transported to one of several storage silos. Two lime handling facilities are in operation and integrated to provide a high degree of flexibility.

Lime produced by #1 and #2 kilns is conveyed to four, 200–ton storage silos via a pan conveyor and bucket elevators or to the large 3,000–ton pebble lime storage silo. Lime to be stored in the large silo is first screened by two 4 ft. x 12 ft. Hewitt–Robins double deck screens located on top of the silo. The screens are equipped with 1/4 in. and 10 mesh decks and only the +1/4 in. oversize is stored in the pebble lime 3,000–ton silo. Fines are stored in a 300–ton concrete silo. The 3,000–ton silo is equipped with an internal spiral chute to prevent damage by free fall.

Pebble lime stored in the small 200 ton silos is screened with a double–deck Tyler F–300 before it is loaded into railcars or trucks.

As necessary, lime is crushed by a J. B. hammermill and conveyed via bucket elevator and belt to the hydrate plant.

The combined systems have a high degree of flexibility allowing products to be stored in a number of silos. Total lime storage in the silos is approximately 4,300 tons or roughly three days production at peak capacity.

### Shaft Kilns

There are six gas–fired shaft kilns on this site, four of which are in operational condition and have a combined capacity of 240 tons per day. The kilns are fed coarse (+4 in. −6 in.) stone by an automated shuttle car system controlled by mechanical level controls within the shaft kiln.

Shaft kiln lime is crushed with a Hazemag crusher prior to entering one of two hydrating units and is preferred for the production of hydrated lime.

### Hydrate Plant

The hydrate plant contains two complete hydrating units with a combined design capacity of 16 tons per hour. One of the hydrators is rated at 10 tons per hour while the other is rated at 6 tons per hour and both hydrators are equipped with high pressure drop Venturi type, wet scrubbers. Milk of lime produced in the scrubbers is recycled to the pre–mixer.

Hydrated lime is stored in four 100–ton elevated silos located above a rail track system. The plant is also equipped with modern bagging and automated palletizing equipment.

Photo A-2-2.
THE OUTPUT FROM THESE SHAFT KILNS IS USED FOR HYDRATED LIME MANUFACTURE.

### Dried Stone Plant

The dried stone plant produces a range of granular and fine products used in the agricultural, animal feed, glass and asphaltic industries and has a capacity of approximately 24 tons per hour. The dried stone plant is fed via two separate truck hoppers.

Coarse rock is reduced in a Hazemag F–50 impact crusher and is lifted by bucket elevator to a 59 ft. x 8 ft. gas–fired Stackett rotary drier. Dried stone is transported by screw conveyor and bucket elevator to a 4 ft. x 14 ft. Tyler "Hummer" screen equipped with 6 and 12 mesh screen decks. Plus 6 mesh oversize is conveyed to a storage silo feeding a regrind circuit. The –6 + 12 mesh product is sold as poultry feed in bag or bulk. Minus 12 mesh undersize from the previous circuit is fed via bucket elevator to a 14 ft. Gayco classifier. Fines from this classification, after scalping over a 4 ft. Sweco vibratory screen, are stored in small silos and sold for use as fillers in asphalt roofing shingles. The coarse fraction from the classifier is glass grade limestone and is stored in a small bulk silo.

## PRODUCTS

### Quicklime

–10 mesh
4 mesh by 10 mesh
–4 mesh
–3/4 in.
–3/4 in. + 4 mesh
–2 in. + 4 mesh

### Hydrate

### Pulverized Stone

Grade 30
Calgro Pulverized Limestone B–2
Calgro Pulverized Limestone B–1
Calgro #3 Grits
Shellroc
Limestone screenings
Limestone chips
2 in. by 1 1/4 in. limestone
1 1/4 in. by 3/4 in. limestone

## REFERENCES

Goudge, 1938, p.260–263
Caley, 1941a, p.51–52
Ehlers and Stumm, 1951
Hewitt, 1960, p. 149–152
Hewitt, 1964a, p. 64
Hewitt and Vos, 1972, p. 69
Oliver, 1976, p.134
Uyeno et al., 1982, p.44

## MAPS

Williams, 1918, GSC 1715
Caley, 1941d, GSC 624A

## A–3 BEACHVILIME LTD. QUARRY AND WEST PLANT

### LOCATION AND OWNERSHIP

This large operating quarry and plant, owned by BeachviLime Ltd., a subsidiary of Dofasco Inc., is located 2.5 km southwest of Beachville in Lots 14, 15 and 16, Concession 3 and 4, Lots 16 to 18, Concession 2, Lots 15 to 17, Concession 3 in the Township of Zorra (North Oxford Township) and Lots 12, 14 and 15, Broken Front Concession in the Township of South West Oxford, (West Oxford Township), Oxford County (Figure A–3–1). The property has been active since 1907, when the Beachville White Lime Co. commenced sales of lime to Cyanamid of Canada Ltd. in Niagara. Cyanamid subsequently opened its own quarry and in 1929 purchased Beachville White Lime. Dofasco acquired the Cyanamid operation in 1973.

### GEOLOGY

A total of 24.1 m of section is exposed in the quarry and consists entirely of the Anderdon Member of the Middle Devonian Lucas Formation. The strata in this quarry consist of bioclastic limestones, interbedded microcrystalline limestones, and calcarenites. Large football–shaped stromatoporoids are quite distinctive here and occur at various horizons. The East Plant (A–2) is located directly northeast of this quarry and exposes a similar section 20 m thick. Overburden averages 24 m in the vicinity of the quarry.

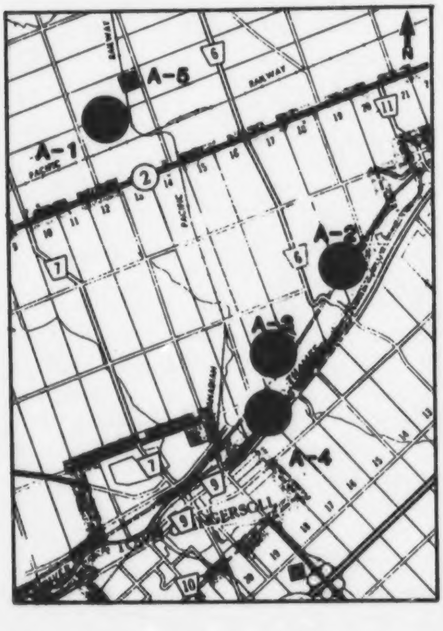


**Figure A–3–1. LOCATION MAP FOR BEACHVILIME LTD. QUARRY.**

### Geological Section

| | | Thickness |
|---|---|---|
| *UNIT 7* | *Lucas Formation, Anderdon Member* | *1.6m* |

Limestone: dark brown, some beds mottled light brown, weathers light brown; sub- to fine crystalline; thin to medium bedded (3–15 cm), contacts are sharp, very irregular and rubbly; abundant bituminous partings with a strong petroliferous odour; some coral debris present; large dark coloured coral heads surrounded by a light brown calcarenite matrix occur at the base; lower contact is sharp and very irregular.

| | | |
|---|---|---|
| *UNIT 6* | *Lucas Formation, Anderdon Member* | *4.1m* |

Limestone: brown, weathers light brown; microcrystalline to subcrystalline (lithographic); thick to massive bedded (beds averaging about 0.7 m each), sharp contacts, slightly irregular, shaly partings and stylolitic; calcarenite beds (fine to medium grained) with fossil debris scattered throughout; calcite mineralization present in fractures, orange–pink iron staining also present; abundant coralgal debris in some zones; lower contact is sharp, slightly irregular and slightly bituminous.

| | | |
|---|---|---|
| *UNIT 5* | *Lucas Formation, Anderdon Member* | *0.8m* |

Limestone: medium brown, weathers medium to light brown; fine to medium crystalline; one massive bed; contacts are sharp, slightly irregular and bituminous; appears calcarenaceous in some places; large stomatoporoids present (football–like, 4 to 35 cm), dark in colour; lower contact is sharp and almost planar, and stylolitic in places.

| | | |
|---|---|---|
| *UNIT 4* | *Lucas Formation, Anderdon Member* | *6.1m* |

Interbedded calcarenites and limestones (lithographic): tan to medium brown, weathers brown; microcrystalline and fine to medium grained; thick bedded (0.9–1.0 m), rare medium beds (10 cm) present, contacts are sharp, stylolitic or shaly; calcite mineralization in patches; coral debris and brachiopods present in calcarenite beds; lower contact is sharp and stylolitic.

| | | |
|---|---|---|
| *UNIT 3* | *Lucas Formation, Anderdon Member* | *4.8m* |

Calcarenite: light to medium brown, weathers brown; fine to medium grained; thick bedded (up to 1 m), contacts are sharp, irregular, stylolitic and bituminous; very fossiliferous with large football–shaped stromatoporoids and coralgal debris; this unit is similar to Unit 5; stromatoporoids are larger and their internal structures are better preserved; one zone is thin bedded, lithographic, and barren of fossils; rare rugose corals and brachiopods present; lower contact is sharp.

| | | |
|---|---|---|
| *UNIT 2* | *Lucas Formation, Anderdon Member* | *6.7m* |

Interbedded calcarenites and limestones (50/50%): medium to dark brown, weathers light to medium brown; microcrystalline and fine to medium grained; thick bedded (up to 1 m), contacts are sharp, some beds are bituminous and stylolitic; the limestones are lithographic in texture, calcite mineralization present in lithographic limestones and in fractures; abundant coralgal debris, rare stromatoporoids; sharp lower contact.

Photo A-3-1.
BEACHVILIME LTD. -
WEST PLANT.

*UNIT 1 Lucas Formation, Anderdon Member* *~7.0m*

Bioclastic limestone: tan to light grey, weathers dark grey; fine to very coarse crystalline; thin to medium bedded, contacts are sharp, very irregular and bituminous; strong bituminous odor; beds have a very irregularly laminated appearance; prominent light and dark banding is present; rare beds are calcarenaceous; calcite mineralization present in some small patches; rare pyrite crystals present; very rare leached chert present replacing fossils; abundant stromatoporoids, coralgal debris, solitary corals, rare bryozoans and brachiopods; base of unit below water level.

*Total thickness* *24.1m*

## QUARRY OPERATIONS

The West quarry is situated north of the CNR tracks and has access to the old quarry and plant through a tunnel beneath the tracks. Overburden ranging from 18 m to 27 m is removed by contract at a 1:1 stripping ratio and, once removed, exposes a 24.1 m section of high-calcium limestone.

Production drilling on the single lift is carried out with an Ingersoll- Rand Drillmaster (BL900) on a 23 ft. by 26 ft. pattern and produces 6 in. diameter holes. The holes are pumped dry before bottom-loading with CIL Magnafrac 300 (or 500), followed by bulk ammonium nitrate prills mixed with diesel fuel for the remainder.

The blasted rock is loaded by a Michigan 475B 12 yd. Payloader and a 6.5 cu. yd. P&H electric shovel onto three 60-ton Wabco Haulpak trucks for haulage to the primary crusher on the quarry floor.

## PROCESSING

The primary crusher is a 42 in. Traylor gyratory. A 36 in. conveyor then carries the crushed stone to a surge pile at the secondary crushing plant. Stone from the surge pile is picked up by another 36 in. sublevel conveyor and subsequently reduced and screened to -2 3/4 in. in the secondary crusher, a 42 in. by 35 in. McLanahan heavy duty double roll.

Feed to the screenhouse and bin building is split between two (5 ft. x 14 ft.) Ty-Rock F800 triple-deck screens equipped with 2 3/4 in. openings on the top deck, 2 in. openings on the middle deck, and 3/4 in. openings on the bottom deck. The +2 3/4 in. stone is recrushed in a 51 in. Telsmith hydrocone, that is in a closed circuit with the screens. The two intermediate sizes, -2 3/4 in. + 2 in. and -2 in. + 3/4 in., are used as kiln feed in the lime operation. The -3/4 in. fines are split between two (5 ft. x 14 ft.) Ty-Rock F600, twin deck screens and -3/4 in. + 5/8 in., -5/8 in. + 1/4 in. and -1/4 in. fines are the products.

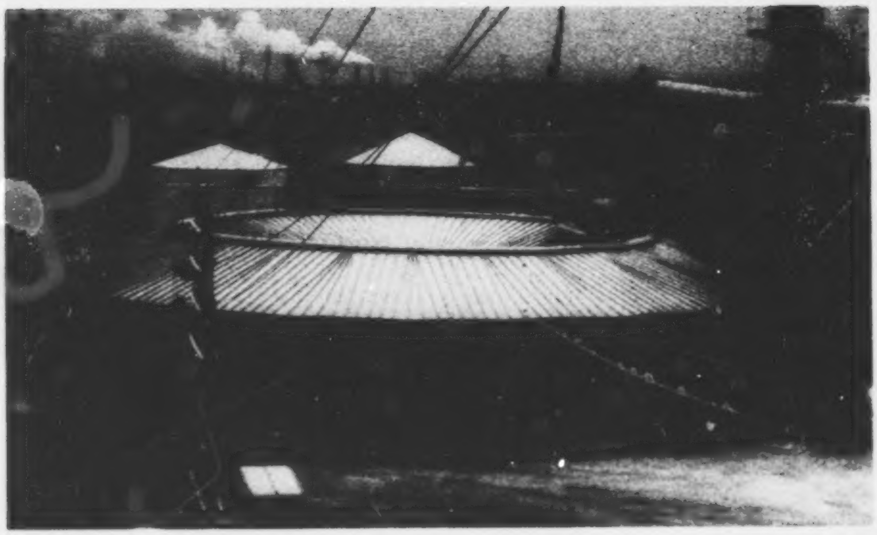
The crushing plant has a capacity of about 550 tons per hour and produces about 1.2 million tons annually.

### Lime Plant

Lime is produced in two gas-fired rotary kilns and one gas-fired rotating hearth Calcimatic kiln. The lime products are used mainly in steel-making, carbide manufacturing, and for water treatment.

The #1 kiln, a F.L. Smidth rotary unit (with preheater) built in 1957, is 276 ft. x 10.5 ft. and has a

**Photo A-3-2.**
**THE CALCIMATIC KILN AT THE BEACHVILIME WEST PLANT IS THE ONLY ONE IN USE IN ONTARIO.**



production capacity of 496 tons of lime per day. Kiln #2 is a Calcimatic unit built in 1967 and has a capacity of 298 tons per day. The kiln has a doughnut-shaped refractory hearth that rotates the stone through two temperature zones up to a maximum of about 1300°C. The gas burners are arranged around the hearth and exhaust gases, which are expelled through a chimney, preheat the fresh kiln feed in the process. Kiln #3, 180 ft. x 12.5 ft., is also a rotary unit with preheater and is capable of producing 660 tons per day.

### Dried Stone Plant

The DSP is similar to the one located at the East operation and is rated at 35 tons per hour.

### PRODUCTS

### Quicklime

150 mesh
1/4 inch by 0 mesh
-3/4 in.
-3/4 in. + 4 mesh
-2 in. + 4 mesh

### Hydrate

### Pulverized Stone

Grade 30
Calgro Pulverized Limestone B-2
Calgro Pulverized Limestone B-1
Calgro #3 Grits
Shellroc
Limestone screenings
Limestone chips
2 in. by 1 1/4 in. limestone
1 1/4 in. by 3/4 in. limestone

### REFERENCES

Goudge, 1938, p.263-264
Caley, 1941a, p.52
Ehlers and Stumm, 1951
Best, 1953, p.111-115
Stumm et al., 1956, p.13
Hewitt, 1960, p.152-155
Hewitt, 1964a, p.65
Hewitt and Vos, 1972, p.68-69

### MAPS

Caley, 1941d, GSC 624A

## A-4 STELCO STEEL QUARRY

### LOCATION AND OWNERSHIP

Stelco Steel operates a plant and quarry 3.5 km southwest of Beachville (Figure A-4-1). The plant and quarry straddle the boundary between the Township of Zorra (North Oxford Township) and the Township of South West Oxford (West Oxford Township). Partly in the Town of Ingersoll, the property covers an area of approximately 593 ha of which about 21 ha are occupied by the quarry.

### GEOLOGY

The quarry exposes 33.4 m of the Anderdon Member of the Middle Devonian Lucas Formation in three lifts (Figure A-4-2). The lower 28.3 m predominantly consist of bioclastic and microcrystalline limestones and cal-

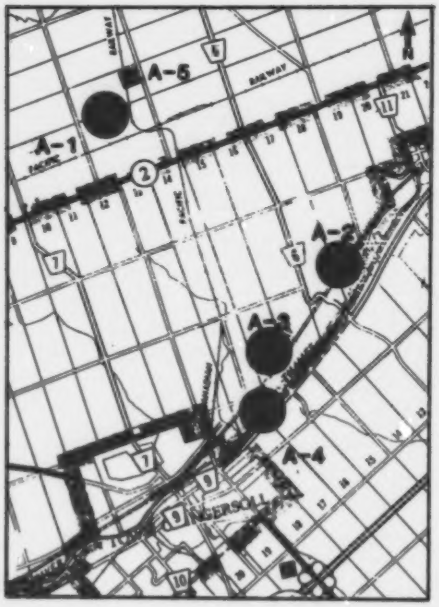


**Figure A-4-1. LOCATION MAP FOR STELCO STEEL QUARRY.**

carenites. Some beds contain prolific amounts of stromatoporoids. These beds are very similar to the strata in the BeachviLime Ltd. Quarry (A–3). The distinguishing feature in this quarry is the top 5.1 m of the Lucas Formation which is a sandy limestone facies of the Anderdon Member. It acts as a distinctive cap rock for the quarry. Overburden averages 7 m in the vicinity of the quarry.

### Geological Section

*Thickness*

*UNIT 5 Lucas Formation, Anderdon Member* *5.1m*

**Sandy limestone: cream–buff, mottled, weathers buff; fine-grained quartz-rich sand in fine-crystalline limestone; thick to massive bedded, contacts are sharp and undulating; acts as a distinctive cap rock; abundant orange coloured staining present; lower contact is sharp.**

*UNIT 4 Lucas Formation, Anderdon Member* *17.5m*

**Interbedded limestones and calcarenites: tan to medium brown, weathers brown; subcrystalline to fine and medium grained; thin to thick bedded (up to 1 m), contacts are sharp and well defined, undulating and stylolitic with abundant bituminous partings; lithographic texture; top 2.7 m is thin bedded; some stylolites develop into shaly partings (up to 4 cm thick); scattered calcite crystals in lithographic limestones; abundant zones of coralgal debris, especially in calcarenites; lower contact is sharp.**

*UNIT 3 Lucas Formation, Anderdon Member* *2.8m*

**Calcarenite: light to medium brown, weathers brown; fine to medium grained; thick bedded (up to 1 m), contacts are sharp, irregular, stylolitic, and bituminous; very fossiliferous with large football-shaped stromatoporoids and coralgal debris; lower contact is sharp.**

*UNIT 2 Lucas Formation, Anderdon Member* *4.5m*

**Interbedded calcarenites and limestones: medium to dark brown, weathers light to medium brown; subcrystalline and fine to medium grained; thick bedded (up to 1 m), contacts are sharp, bituminous and stylolitic partings; lithographic texture; calcite mineralization present in lithographic limestones and along fractures; fossiliferous with abundant coralgal debris and rare stromatoporoids; sharp undulatory lower contact.**

*UNIT 1 Lucas Formation, Anderdon Member* *3.5m*

**Bioclastic limestone: tan to light grey, weathers dark grey; medium to coarse crystalline; thin to medium bedded, contacts are sharp, irregular and very bituminous; possesses a strong bituminous odor; prominent light and dark banding present; some calcarenaceous beds present; abundant coralgal debris.**

*Total thickness* *33.4m*

## QUARRY OPERATION

The loose overburden, which consists essentially of sand and till, is removed by a Bucyrus–Erie 3 1/4 yd. electric shovel and 22–ton Euclid haul trucks for use as backfill in quarried–out areas. The sandy limestone caprock to the quarry is loosened by drilling and blasting and removed by loader and truck for use as fill or for sale as riprap.

High purity limestone (98.5% $CaCO_3$) is removed from two lifts; the upper 15.8 m high and the lower 14.3 m high. Blastholes (6.25 in. diameter) are drilled with a diesel rotary drill on a 5.8 m x 6.1 m pattern. Tovex, Hydromex T–3 and AN/FO are used as explosives at a rate of 0.32 lb./ton. Due to the proximity of the Town of Ingersoll, all blasts are monitored for noise and vibration.

The broken rock is removed by a 7 yd. Cat 988B loader and transferred to 22–ton Euclid trucks for haulage to the primary crusher.

The quarry has a rated capacity of 810,000 tons of limestone per year operating on five shifts per week.

## PROCESSING

The primary crusher, a 48 in. x 60 in. Traylor jaw, is located on top of the lower lift. The crushed stone is transported to the secondary crusher building by a 42 in. conveyor and discharged onto a 5 ft. x 14 ft. Tyler F800 single deck scalping screen. The screen has a split deck with 4 1/2 in. and 10 in. openings; +10 in. stone is sent to the secondary crusher; –10 in. + 4 1/2 in. stone is sent either to a bin as open hearth flux stone or to the secondary crusher; –4 1/2 in. stone is sent to a double deck 5 ft. x 10 ft. Tyler F600 screen (for removal of fines to a storage bin) and the –4 1/2 in. + 3/8 in. product is car-

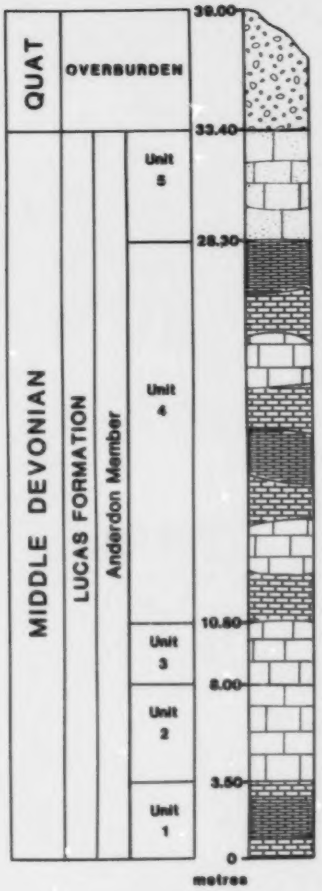


**Figure A-4-2. STRATIGRAPHIC COLUMN FOR STELCO STEEL QUARRY.**

ried on a 36 in. conveyor belt to the bin building. The −4 1/2 in. + 3/8 in. stone is discharged onto a double-deck 6 ft. x 14 ft. Tyler screen together with the −10 in. + 4 1/2 in. stone, and this combination produces −10 in. + 4 1/2 in. open hearth flux stone, −4 1/2 + 2 1/4 in. shaft kiln feed, and −2 1/4 in. fines for further processing.

The −2 1/4 in. stone is transferred by conveyor to two triple-deck Tyler F880 screens which generate −2 1/4 in. + 1 3/4 in. blast furnace flux stone, −1 3/4 in. + 1/2 in. rotary kiln feed, −1/2 in. + 3/16 in. small stone bottom and −3/16 in. screenings. Various blends of −2 1/4 in. stone can be used, as needed, to generate −3/16 in. sinter flux stone via a C38 Pennsylvania impactor in closed circuit with two Nordberg rod deck screens.

## LIME PLANT

The Lime Plant consists of three vertical shaft kilns (installed in 1959) and a single Kennedy Van Saun short rotary kiln (installed in 1971); all are fired by natural gas. The vertical shaft kilns are charged with −4 1/2 in. + 2 1/4 in. limestone and have a combined capacity of 300 tons of lime per 24 hours. The KVS rotary kiln is charged with −1 3/4 + 1/2 in. limestone and has a rated capacity of 420 tons per 24 hours.

The shaft kilns discharge to elevator #1 and a lump lime silo that feeds a stationary grizzly, or is routed directly (by-passing the silo). Oversize from the grizzly is sent to a McLanahan double-roll crusher; the product rejoins the fines from the grizzly and is conveyed to elevator #2. The lime is fed to a triple-deck 4 ft. x 8 ft. Dillon screen and oversize is returned to the roll crusher; mid-sizes go to one of four bins (totalling 3,000 tons storage capacity), and the fines go either to load-out via elevator #3. Lime from the rotary kiln is added to the elevator #2 feed.

Lime is recovered from the storage bins to a 5 ft. x 12 ft. double-deck Tyler screen that routes the coarse material onto load-out, mid-size go either to load-out or return to elevator #2 and fines go to elevator #2. The lime plant has a rated capacity of 243,000 tons per year, on a 24 hour a day basis.

## PRODUCTS

Riprap
Lime for steel-making flux.
Crushed and sized limestone.

## REFERENCES

Goudge, 1938, p.264

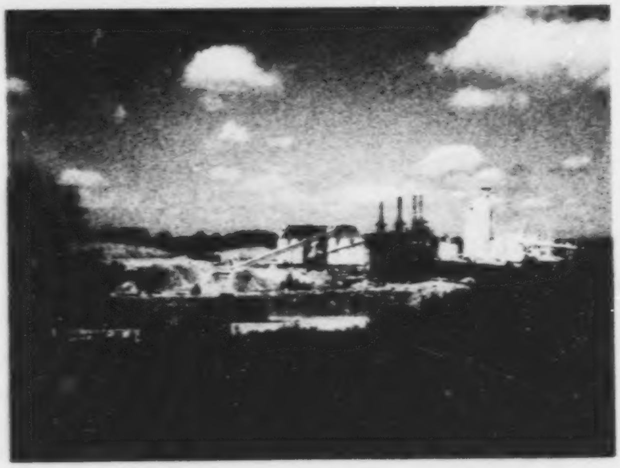


**Photo A-4-1. STELCO STEEL LIME PLANT.**

Caley, 1941a, p.52
Ehlers and Stumm, 1951
Best, 1953, pp.107–111, 167–168
Stumm et al., 1956, p.14
Hewitt, 1960, p.155
Hewitt, 1964a, p.65
Hewitt and Vos, 1972, p.71–73
Winder and Sanford, 1972, p.67
Winder et al., 1975, p.151–152
Uyeno et al., 1982, p. 43–44
Telford and Johnson, 1984, p.32

### MAPS

Caley, 1941d, GSC 624A

## A-5 FEDERAL WHITE CEMENT LTD. – WOODSTOCK PLANT

### LOCATION

Federal White Cement Ltd. operates a dry process cement plant near Woodstock, Ontario; the only white cement producer in Canada. The plant is located immediately to the north of the Lafarge Canada Inc. plant in the Township of Zorra, Oxford County, on Zorra Concession Road 3, approximately 23 km west of Woodstock, as shown in Figure A–5–1.

### PROCESSING

The plant was built in 1979 to designs provided by Lafarge Canada Inc. The plant uses a Fuller oil/gas/coke–fired kiln. No other details on the equipment and production process are available from the company.

### PRODUCT

The plant has truck and rail shipping facilities. Although white portland cement is as durable as standard portland cement it is used mainly in decorative architecture where the concrete surface is exposed. Because of this feature, white cement is able to command a high price.

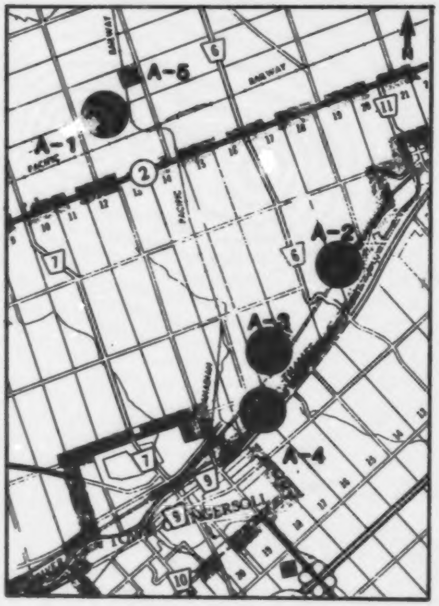


Figure A-5-1. LOCATION MAP FOR WOODSTOCK PLANT.

# Wingham District

## INTRODUCTION

Wingham District is located in Southwestern Ontario and is bounded by Lake Huron to the west and the Districts of Owen Sound, Cambridge and Aylmer to the north, east and south, respectively.

Nineteen quarries in the Wingham District are documented in the quarry inventory (*see* Appendix IV, Vol-

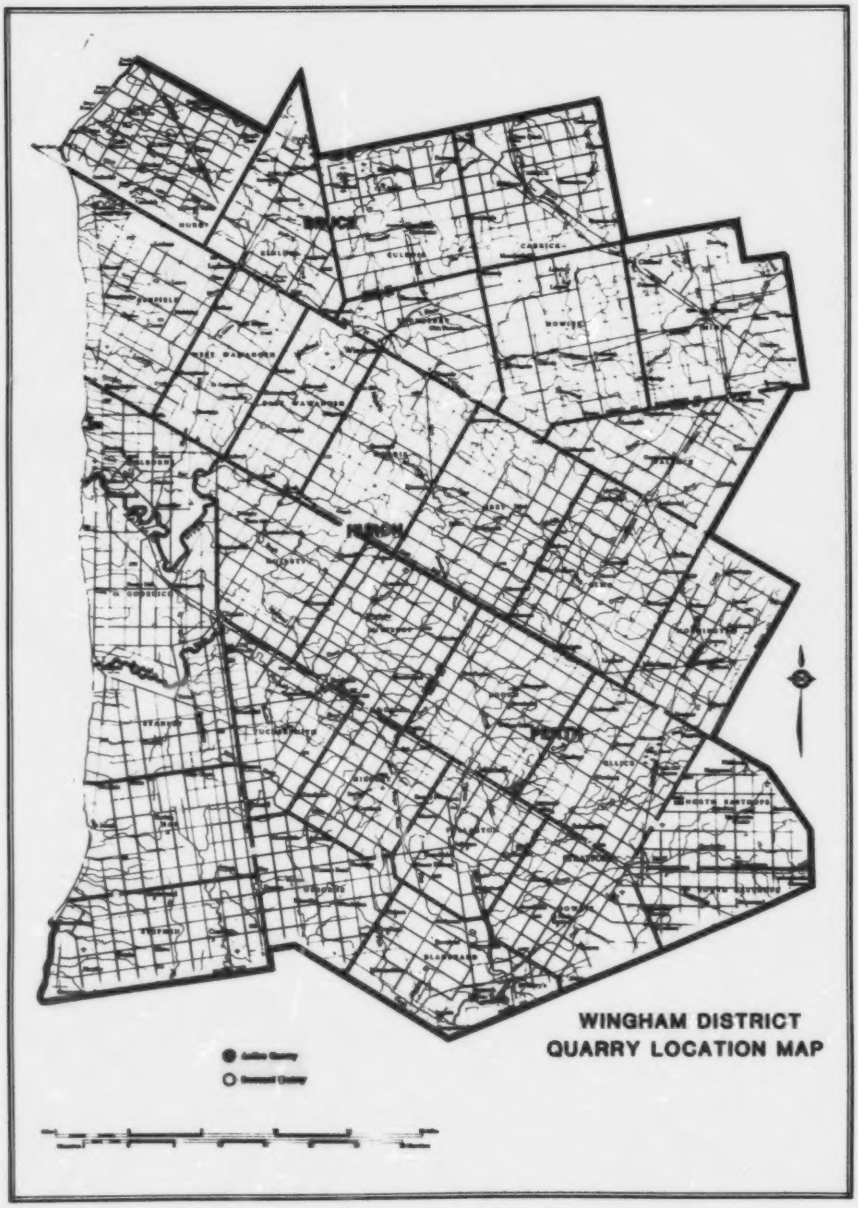

BRUCE
HURON
PERTH
WINGHAM DISTRICT
QUARRY LOCATION MAP

Figure W-0-1. WINGHAM DISTRICT QUARRY LOCATION MAP.

ume I), only one of which, the St. Marys Quarry (W–1) is currently active.

### REGIONAL GEOLOGY

The Wingham District exhibits low relief and, due to thick Quaternary deposits, outcrops are sparse. The district is criss–crossed by numerous westward flowing streams and is bordered by Lake Huron to the west. The hummocky topography along the northern edge of the district is the surface expression of the Formosa Reef Complex, a reefal facies of the Amherstburg Formation (Detroit River Group). It is characterized by small knolls and hummocks, which were excavated for building stone at the turn of the century.

Rock exposures in the area are mainly found along river valleys near the towns of Gorrie, Goderich, Brussels, and St. Marys (where the only operating quarry is located), along with minor outcrops of the Formosa Reef Limestone facies near the town of Formosa. A typical section of the Formosa Reef Limestone is exposed 4 km north of Formosa. The stratigraphy present in subcrop includes units from the Upper Silurian Salina Formation to the Middle Devonian Dundee Formation (see Figure W–0–1). Most of these units are Michigan Basin rock units, but formational boundaries are difficult to define in the subsurface due to interfingering of Appalachian Basin units from the southeast.

The St. Marys Cement Co. Quarry (W–1), located west of the Thames River in the Town of St. Marys (Figure W–0–1), exposes 18.2 m of section from the Middle Devonian Detroit River Group (Lucas Formation) and the Middle Devonian Dundee Formation (Figure W–0–2). The Lucas Formation in the quarry here consists of a grey, very fine– to fine–crystalline, thin–to medium–bedded dolomitic limestone. It is sharply and disconformably overlain by the Dundee Formation, a grey, fine– to medium–crystalline, thin– to thick–bedded, somewhat shaly limestone. Other small and water filled abandoned quarries exist within the town and are of the same lithology, except those east of the Town of St. Marys where the rocks are Silurian in age. The Upper Silurian Bertie Formation occurs in some older quarries because of a pronounced anticlinal fold in the subsurface which has uplifted the underlying strata.

### LIMESTONE INDUSTRIES

The principal limestone industry in Wingham District is cement production, from Middle Devonian limestones and dolomitic limestones of the Lucas and Dundee Formations. The single active quarry, St. Marys (W–1) also produces minor amounts of crushed stone.

The cement production in 1986 for Perth County was approximately 573,000 tonnes (1987 Ontario Mineral Score). The St. Marys Quarry (W–1) markets a wide variety of products including, but not restricted to, Normal Portland, High Early Strength Portland, Sulfate Resisting Portland, Moderate Portland, Low Heat of Hydration Portland and Masonry Cement.

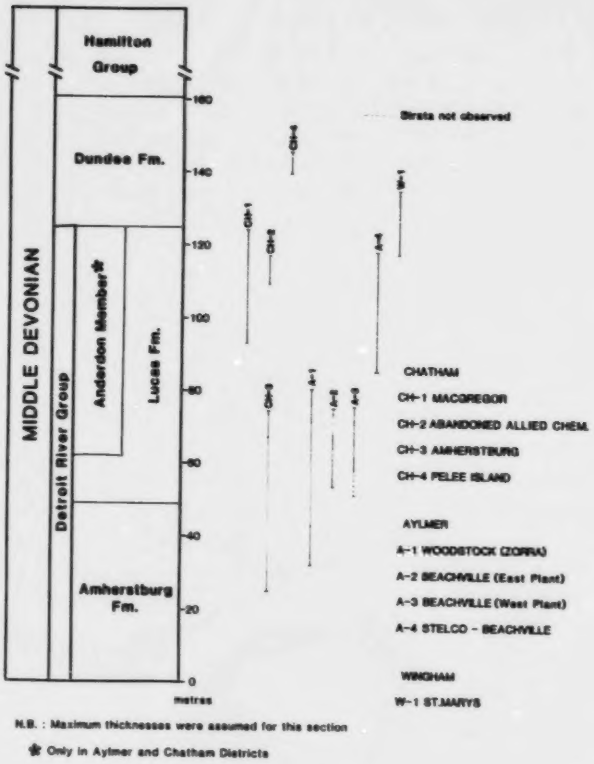

Hamilton Group
Dundee Fm.
MIDDLE DEVONIAN
Detroit River Group
Anderdon Member*
Lucas Fm.
Amherstburg Fm.
160
140
120
100
80
60
40
20
0
metres
CH-1
CH-2
CH-3
CH-4
A-1
A-2
A-3
A-4
W-1
Strata not observed
CHATHAM
CH-1 MACGREGOR
CH-2 ABANDONED ALLIED CHEM.
CH-3 AMHERSTBURG
CH-4 PELEE ISLAND
AYLMER
A-1 WOODSTOCK (ZORRA)
A-2 BEACHVILLE (East Plant)
A-3 BEACHVILLE (West Plant)
A-4 STELCO - BEACHVILLE
WINGHAM
W-1 ST.MARYS
N.B. : Maximum thicknesses were assumed for this section
* Only in Aylmer and Chatham Districts

**Figure W–0–2.** STRATIGRAPHIC COLUMN SHOWING PRINCIPAL QUARRIES IN AYLMER, CHATHAM AND WINGHAM DISTRICTS.

## W–1 ST. MARYS CEMENT COMPANY — QUARRY AND PLANT

### LOCATION AND OWNERSHIP

The quarry and cement plant of St. Marys Cement Company is located on the southern outskirts of St. Marys. The plant is located on the east side of the north branch of the Thames River, while the quarry is located approximately 0.8 km to the west on the west side of the river in Concessions 16 and 17, Blanshard Township, Perth County as shown in Figure W–1–1.

The Middle Devonian limestone in the St. Marys area has been a source of stone products since the mid–nineteenth century. Initially, small quarries were opened along the banks of the Thames River, both south and north of the village, to extract stone to supply the lime kilns built adjacent to the quarries. This lime was commonly used locally as the land was opened to agriculture.

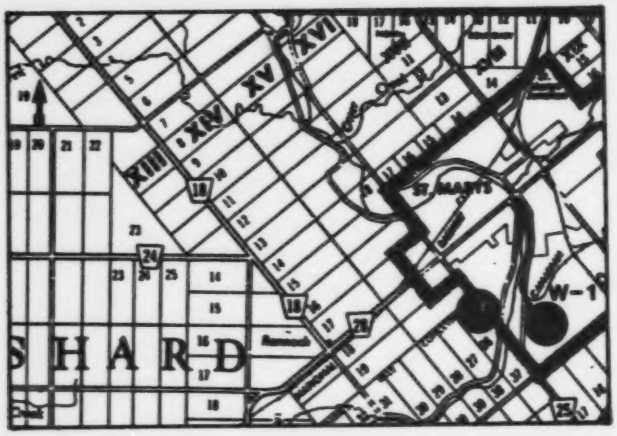


Figure W-1-1. LOCATION MAP FOR ST. MARYS QUARRY.

In addition to lime production, the thicker-bedded limestones were quarried for building stone. These operations also produced rough stone which was used in foundations, sills, lintels and coursings. A variety of dressed stone was provided by some quarries. These stone products were used across southwestern Ontario, as well as in various buildings in Toronto. Other products from these quarries included crushed stone (commonly the waste rock from the building stone operations), used in local road construction, flux stone supplied to the blast furnaces in Hamilton and limestone used in the manufacture of beet sugar. Most of these lime and building stone operations had ceased by the turn of the century, although a few did survive into the early twentieth century.

In 1912 the St. Marys Cement Company began to use the limestones south of St. Marys for the production of portland cement. The operations soon expanded and began to incorporate many of the older, now abandoned, quarries along the Thames River. Today the St. Marys Cement Company's quarries extend along both banks of the river.

The plant is a 2,000 tonne per day dry process kiln situated in the floor of the old quarry. A wet process, 4-kiln cement plant is located close by the new plant, but is not operated, except for finish grinding and storage purposes.

## GEOLOGY

The new quarry exposes an 18 m section of Middle Devonian limestone and dolomitic limestone of the Dundee and Lucas Formations, respectively, (Figure W-1-2) in a single bench.

The new quarry was opened when magnesia and alkali contents in the old quarry were found to be increasing as it was developed to the southeast. The rocks of the Dundee and Lucas Formations strike northwest and dip to the southwest at 2.8 m per kilometre. Quaternary overburden in the area of the new quarry ranges up to 12 m thick and averages 7 to 9 m in thickness.

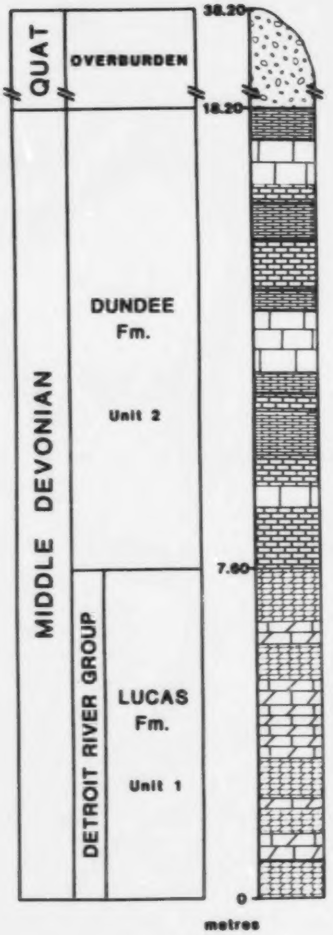


Figure W-1-2. STRATIGRAPHIC COLUMN FOR ST. MARYS QUARRY.

The lower 7.6 m consist of very fine- to fine-crystalline, thin- to medium-bedded, banded Lucas Formation limestone. These rocks are light grey to light buff, weather to a light brown, and contain a microcrystalline bed near the floor of the quarry. Dolostones averaging 17% MgO underlie the quarry floor for at least 30 m.

Overlying the Lucas Formation are 10.6 m of Dundee Formation limestones which are very fine to fine crystalline, grey to buff and in beds 3 to 40 cm in thickness with thin grey to black shale partings. The lower

**TABLE W-1-1. DRILL HOLE ANALYSES W-1 ST. MARYS CEMENT COMPANY ST. MARYS QUARRY.**

| Hole | Formation | Thickness (m) | CaO (%) | MgO (%) |
|---|---|---|---|---|
| F2 | Dundee | 12.80 | 52.70 | 1.40 |
|  | Lucas | 6.55 | 50.47 | 2.96 |
| F3 | Dundee | 12.65 | 52.06 | 1.25 |
|  | Lucas | 7.47 | 52.21 | 2.76 |
| F4 | Dundee | 12.80 | 52.16 | 1.54 |
|  | Lucas | 6.71 | 50.93 | 3.74 |
| F7 | Dundee | 12.65 | 52.61 | 1.22 |
|  | Lucas | 7.16 | 52.46 | 2.04 |

*Data provided by St. Marys Cement Company.*

contact of the Dundee Formation is sharp and erosional and is marked by a sulphurous clay seam, and by a rusty porous dolostone at the top of the Lucas Formation.

Exploration diamond drilling by St. Marys Cement Company tested the stratigraphy at various locations, within the licensed area. The analytical results from the drill core, as presented in Table W-1-1, are reported by St. Marys Cement to be representative of the chemical composition of the property stratigraphy.

Only CaO and MgO assays are available as the stone delivered to the raw mill has been so consistent. No deleterious elements such as sulphur, chlorine and phosphorous are reported.

### Geological Section

*Thickness*

*UNIT 2 Dundee Formation* *10.6m*

Limestone: light grey-brown, weathers light grey; fine to medium crystalline; thin to thick bedded (3 to 40 cm), contacts are sharp, slightly irregular, and appear erosional and shaly; lower 25 cm is laminated with rip-up clasts and conglomerates, top of this bed is scoured with calcarenite laminations; scattered colonial coral heads (with oil seeps); scattered erosional horizons with thin clay seams; a 10 cm thick bed (5.4 m from base) is very fossiliferous (abundant crinoids and brachiopods, rare corals, trilobites, and bryozoa), and is clayey and recessive; lower contact is sharp at a sulphurous clay seam.

*UNIT 1 Lucas Formation* *7.6m*

Dolomitic limestone: tan, grey in some places, weathers same, though some areas are stained by sulphurous water; very fine to fine crystalline; thin to medium bedded (3 to 35 cm), contacts are sharp with thin shaly partings and slightly irregular; two prominent grey bands (0.95 m from the top, 0.20–0.25 cm thick) are present and are laminated, banded, and contain sedimentary features; some clay partings occur and weather platy; rare coral debris is present especially in clay seams; one clay seam, 1.3 m from the base, is filled with marcasite crystals and directly overlies a possible ash bed.

*Total thickness* *18.2m*

## QUARRY OPERATION

Stripping of the overburden is done with a 3-yd. Marion electric shovel, loading a fleet of Euclid rear-dump trucks.

The quarry face is being developed on three sides at equal rates. Drilling is carried out by a 15 cm Gardner-Denver rotary drill on a 6 m x 6.6 m pattern. Holes are drilled to the quarry floor. Blasting is by AN/FO at a rate of 3,000 kg per 10 holes, with a fuel/hydro mix at a rate of 25 kg per hole using the I-L blasting system. Rock fragmentation is good, with no secondary crushing required.

Water inflow in the quarry averages approximately 1,000 gallons per minute, handled by an 8 in. submersible pump having a capacity of 1,500 gallons per minute.

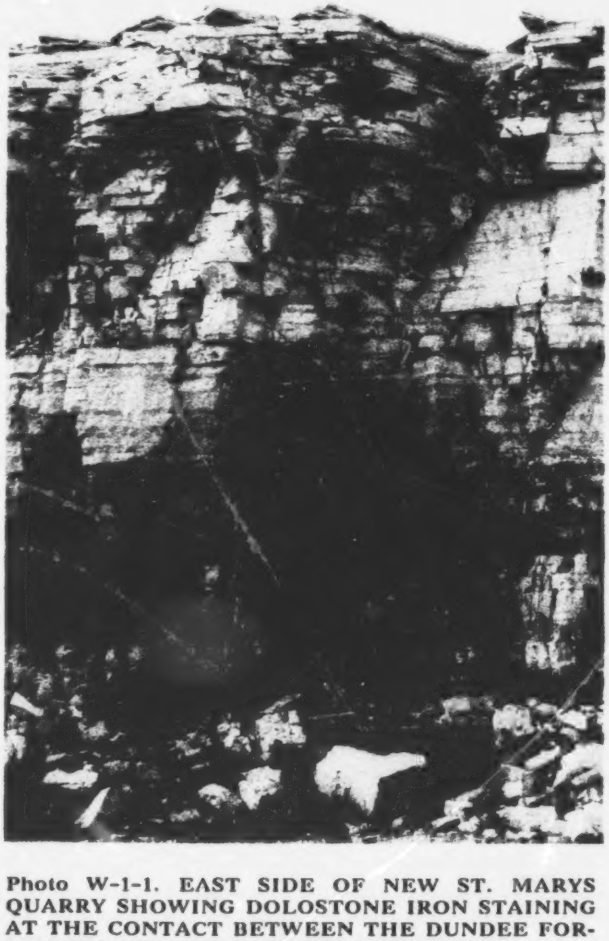


**Photo W-1-1. EAST SIDE OF NEW ST. MARYS QUARRY SHOWING DOLOSTONE IRON STAINING AT THE CONTACT BETWEEN THE DUNDEE FORMATION AND THE DETROIT RIVER GROUP.**

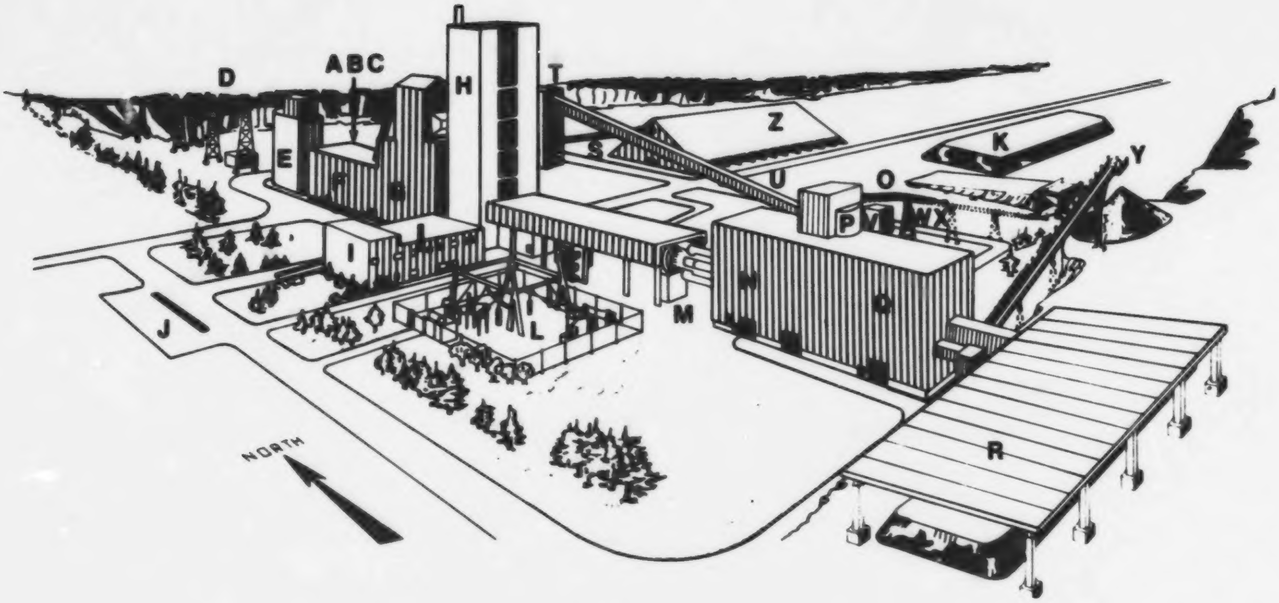


Figure W-1-3. GENERAL LAYOUT OF ST. MARYS CEMENT.

## PROCESSING

A general layout of the St. Marys Plant is shown in Figure W–1–3.

The shot rock is recovered by a CAT 988B loader into three 40–ton Euclid rear–dumps. A 5–yd. Bucyrus–Erie electric shovel is located in the quarry as a standby. Stone is hauled approximately 600 m to a Traylor 52 in. gyratory primary crusher located in the quarry floor. The crusher is set at 6 in. and has a capacity of 1,000 tonnes per hour.

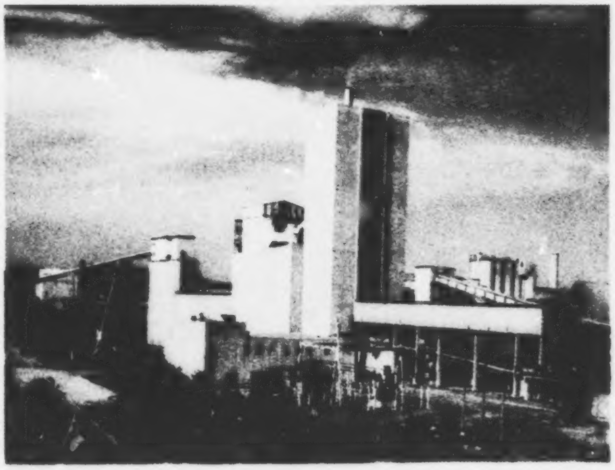


Photo W-1-2. ST. MARYS CEMENT PLANT.

Primary crushed stone is transported from the new quarry by a 42 in. covered belt conveyor approximately 800 m, to the secondary crusher located at the old cement plant. Here the material is reduced to –1 in. in a Pennyslvania impactor. After secondary crushing, the raw stone is conveyed to a 2500–ton storage silo located at the new plant.

Clay is obtained from a pit directly south of the new plant. The clay is removed by a CAT 245 3–yd. backhoe to a 40–ton, rear–dump truck, which transports the material to a covered area where it is fed to a variable speed Rexnord belt conveyor and thence to the clay mill. The clay mill is a 4.7 m diameter semi–autogenous Aerofall mill which grinds the material to –50 mesh, and has a capacity of 1,600 tonnes per day. The clay is dried and beneficiated and then pumped by an F.L. Smidth fluxo pump approximately 200 m to two 2500–ton storage silos adjacent to the raw limestone silo.

Other raw materials, chiefly silica flour, alumina and mill scale, are stored in a quadrated silo. Each quadrant holds 625 tons. Silica flour is purchased from Indusmin Ltd. in Midland, while mill scale is supplied from Hamilton.

Limestone and clay in a 2:1 ratio and other raw materials are ground in an Allis–Chalmers/Pfeiffer MPS 3150/2050 roller mill which uses waste kiln gases for drying the material. The mill has a bowl diameter of 3.15 m and three 2.05 m diameter rollers driven by a 750 kw motor. Material is ground to 90% passing 200 mesh at a rated capacity of 180 tonnes per hour.

The ground raw mill feed is pneumatically conveyed to the two 4,500 m$^3$ homogenizing silos, where it is blended using a GATX–Fuller airmerge system. Prior to homogenizing, the mill exit gases and the ground feed are processed through an American Air Filter/Elex electrostatic precipitator. The homogenized kiln feed overflows from the homogenizing silos to an 1,100 m$^3$ kiln feed silo.

## KILN

Raw kiln feed is drawn from the kiln feed silo through Fischer vee–ball valves, and is carried to the top of the preheater tower by a double string of Webster belt buckle elevators and GATX–Fuller airslides. Each string has a rated capacity of 180 tonnes per hour. The raw kiln feed is discharged from a constant level box through two Fischer vee–ball valves onto two Merrick weighfeeders and thence into the preheater system.

The preheater is a F.L. Smidth two–string, four–stage suspension system. The four first stage cyclones are 11.5 ft. in diameter, while the second and third and fourth stages are 16.5 ft. in diameter. There is a maximum 5% by–pass on the preheater for control of alkalis.

Kiln feed temperatures reach 1,000 degrees C at the bottom of the preheater. The preheater gas is treated with two gas conditioners.

The dry process kiln is an F.L. Smidth design measuring 15.5 ft x 325 ft. and rated at 2,000 tonnes per day. The primary fuel is pulverized coal, with a capability for gas on dual coal/gas firing. Clinker cooling is in ten 6.4 ft. diameter x 67 ft. Unax planetary coolers. Additional clinker cooling is provided by an F.L. Smidth water cooling system attached to the planetary coolers. Cooled clinker is discharged to a Hazemag APK–40 impact crusher to reduce the larger clinker pieces, then transferred by conveyor belt to either a large pre–cast concrete 45,000 tonne storage hall adjacent to the new plant or to storage in silos at the old plant. Storage at the old plant is rated at 7,250 tonnes.

Finish grinding takes place in the old plant. Clinker and gypsum are fed to either two 10 ft. x 15.5 ft. 750 hp single chamber ball mills, which are run in tandem; or two 9.5 ft. x 26 ft. 1,250 hp two–chamber Unidan mills. The mills are in closed circuit with Sturtevant air classifiers. Cement is typically ground to a Blaine number of 3,700 for Type 10 product.

Shipment is by bulk road and rail transport and in bags. Rail shipment represents only a small proportion of tonnage.

Process control for the plant is achieved by an Interautomation digital system operated from a Nova 2 computer. Analog instrumentation provides a back–up system.

## PRODUCTS

Normal Portland
Moderate Portland
High Early Strength Portland
Low Heat of Hydration Portland
Sulfate Resisting Portland
Masonry Cement

## REFERENCES

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## MAPS

Caley, 1942, GSC Map 691A

# Chatham District

## INTRODUCTION

Chatham District is the westernmost district in the Southwestern Region of southern Ontario, bounded on the north by Lake Huron, on the west by the St. Clair River, Lake St. Clair and the Detroit River, on the south by Lake Erie and on the east by Aylmer District and includes Essex, Kent and Lambton Counties (Figure CH–0–1).

Fourteen quarries are documented in the Chatham District Quarry Inventory; seven are licensed. Three of the seven are currently active with the balance being operated on an intermittent basis.

All of the active quarries and one historic quarry were visited during the study and include:

| | |
|---|---|
| *CH–1* | *General Chemical Canada Ltd. – MacGregor Quarry (active)* |
| *CH–2* | *General Chemical (Allied Chemical) Quarry (abandoned)* |
| *CH–3* | *Amherst Quarries (1969) Ltd. – Amherstburg Quarry (active)* |
| *CH–4* | *670026 Ontario Limited – Pelee Island Quarry (active)* |

## REGIONAL GEOLOGY

This district has relatively low relief, moderate to thick glacial cover, and is surrounded on three sides by the Great Lakes. The two bedrock highs which cross the district (the Algonquin and Findlay Arches), meet at a tectonic low called the Chatham Sag that trends northwest to southeast and is centered on the City of Chatham (see Figure 1.4, Volume I). These tectonic features are not particularly visible in surface topography. No outcrops occur in the extreme southwestern corner of the district (Essex County), although the Dundee Formation outcrops on Pelee Island. In the Thedford and Arkona area, some outcrops of the Hamilton Group and Kettle Point Formation occur.

The Detroit River Group, approximately 180 m thick in the district, is represented by the Amherstburg and Lucas Formations (in ascending order) (Figure CH–0–2). The Sylvania Sandstone, the basal member of the Amherstburg Formation, is also present in the district (but not exposed) and ranges in thickness from zero to 30 m from east to west across Essex County. It consists of a pure white, fine–grained, quartz–rich sandstone with well rounded grains and is conformably overlain by the dolostones of the Amherstburg Formation. The Amherstburg is best exposed in the Amherstburg Quarry (CH–3) where it consists of a medium– to massive–bedded, laminated bituminous dolostone with some zones of oolitic, bioclastic and coralgal–rich limestones, and rare calcarenites. The contact with the overlying Lucas Formation is present in the Amherstburg Quarry, but is transitional and difficult to pinpoint. The Lucas Formation consists of a variety of lithologies including bituminous dolostones, coralline bioclastic limestones and calcarenites. It can be very fossiliferous with abundant stromatoporoids. The Anderdon Member occurs in the upper portion of the Lucas Formation and is a high calcium, microcrystalline to very fine–crystalline, vuggy limestone. It is well exposed in the MacGregor Quarry (CH–1) and in the abandoned Allied Chemical Quarry (CH–2). A calcareous sandstone facies of the Anderdon Member can also be seen in the latter quarry.

The Detroit River Group is disconformably overlain by the Dundee Formation which subcrops extensively in Essex County beneath the Quaternary deposits. The upper portion of the Dundee Formation forms outcrops on Pelee Island and one operating quarry, Pelee Island Quarry (CH–4), exposes 6 m of a thin– to massive–bedded, fine– to medium–crystalline, bituminous bioclastic limestone. The Dundee Formation is succeeded by the Middle Devonian Hamilton Group which has a maximum thickness of 15 m in Essex County, increasing to approximately 93 m around the Thedford/Arkona area. It consists of the following formations (in ascending stratigraphic order): the Bell, Rockport Quarry, Arkona, Hungry Hollow, Widder and Ipperwash Formations. Lithologies range from shales to limestones. The upper portion of the Hamilton Group (Arkona to Ipperwash Formations) outcrops in the Thedford/Arkona and Ipperwash Beach areas. Several small quarries, now abandoned, around the Village of Thedford expose strata of the thin Widder Formation, essentially a fossiliferous shaly and bioclastic limestone.

The Hamilton Group is overlain by the Upper Devonian Kettle Point Formation which outcrops along the Lake Huron shoreline at the Kettle Point Indian Reservation No. 44. It is a dark grey to black siliceous shale with large calcareous concretions (locally called kettles). The Kettle Point Formation is succeeded in Ontario by the Port Lambton Group where it is represented by the Bedford Formation, a soft, grey shale. The Bedford Formation does not outcrop in Ontario and is restricted in subsurface to a small area in Lambton County bordering the St. Clair River south of Sarnia.

The two operating quarries in Essex County (CH–1 and CH–3) utilize both the Amherstburg and Lucas Formations for road construction and riprap. The MacGregor Quarry (CH–1) excavates the pure limestones of the Lucas Formation for chemical lime. The Dundee Formation is extracted from the quarry of 670026 Ontario Limited on Pelee Island where it is used as a source for aggregate. In the past, the abandoned

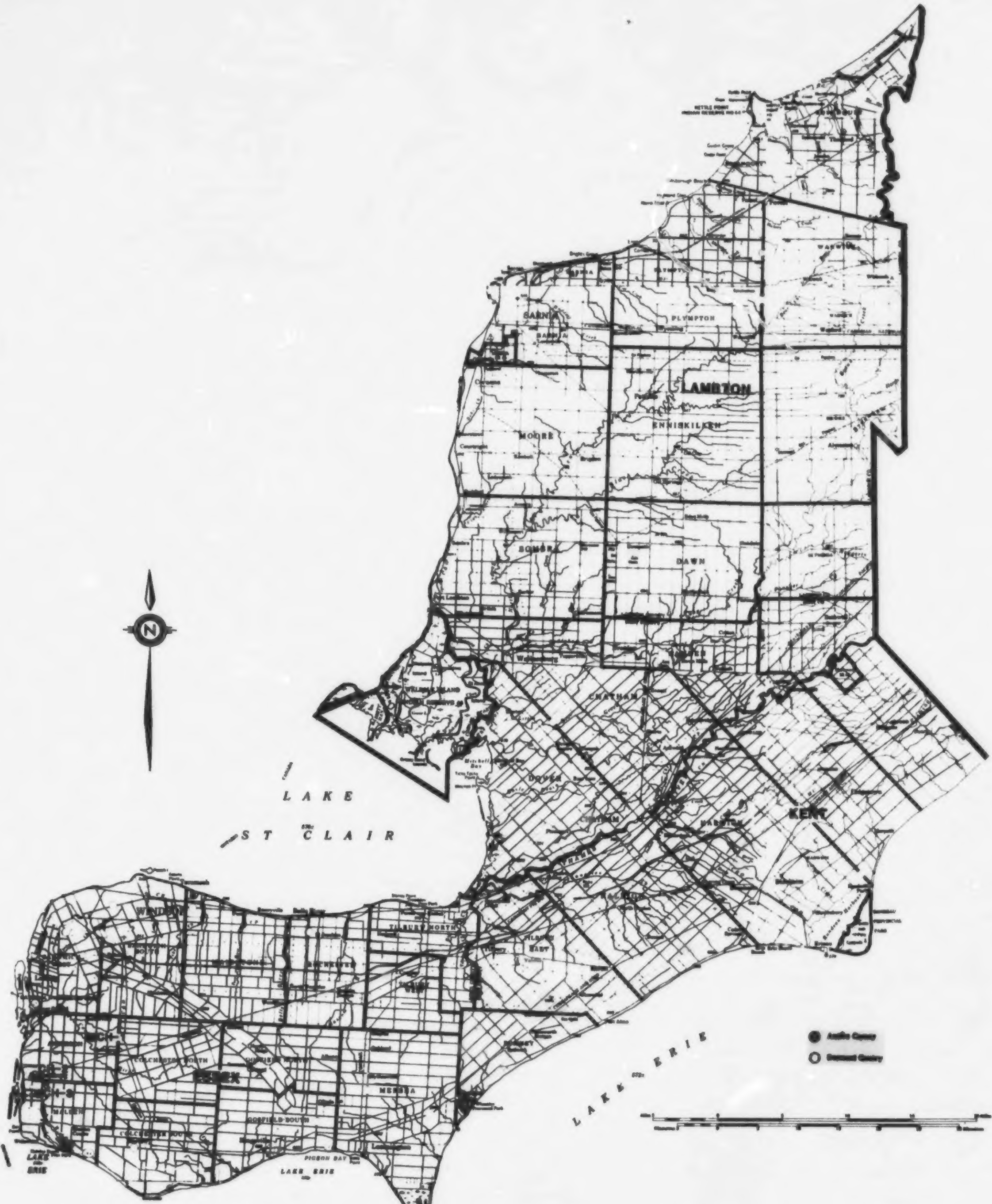
SARNIA
PLYMPTON
LAMBTON
ENNISKILLEN
MOORE
SOMBRA
DAWN
CHATHAM
DOVER
KENT
N
LAKE ST CLAIR
WINDSOR
TILBURY NORTH
COLCHESTER SOUTH
ESSEX
MERSEA
GOSFIELD SOUTH
PIGEON BAY
LAKE ERIE
LAKE ERIE
PELEE PASSAGE
Active Quarry
Dormant Quarry
CHATHAM DISTRICT
QUARRY LOCATION MAP

Figure CH-0-1. CHATHAM DISTRICT QUARRY LOCATION MAP.

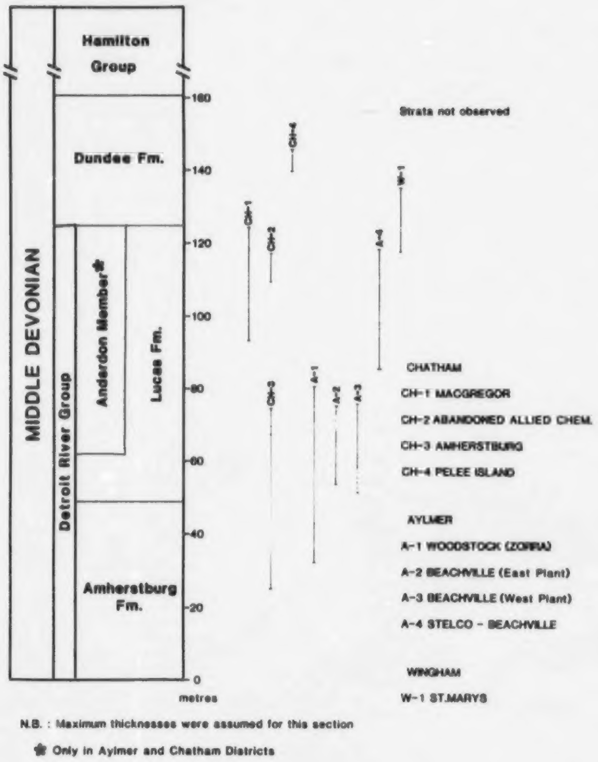
Hamilton Group
Dundee Fm.
MIDDLE DEVONIAN
Detroit River Group
Anderdon Member*
Lucas Fm.
Amherstburg Fm.
160
140
120
100
80
60
40
20
0
metres
CH-4
CH-1
CH-2
CH-3
A-1
A-2
A-3
A-4
W-1
Strata not observed
CHATHAM
CH-1 MACGREGOR
CH-2 ABANDONED ALLIED CHEM.
CH-3 AMHERSTBURG
CH-4 PELEE ISLAND
AYLMER
A-1 WOODSTOCK (ZORRA)
A-2 BEACHVILLE (East Plant)
A-3 BEACHVILLE (West Plant)
A-4 STELCO - BEACHVILLE
WINGHAM
W-1 ST.MARYS
N.B. : Maximum thicknesses were assumed for this section
* Only in Aylmer and Chatham Districts

Figure CH-0-2. STRATIGRAPHIC COLUMN SHOWING PRINCIPAL QUARRIES OF AYLMER, CHATHAM AND WINGHAM DISTRICTS.

quarries around the Village of Thedford worked the shales from the Widder Formation to produce drainage tile.

### LIMESTONE INDUSTRIES

The limestone industries in the Chatham District include chemical–metallurgical stone, lime, aggregate and building stone. Stone production in 1985 and 1986, as reported by the Ministry of Natural Resources, amounted to about 1,840,000 tonnes and 1,970,000 tonnes, respectively; approximately 50% as chemical–metallurgical stone with the balance being used in the construction industry as road and concrete aggregate. The building stone component of the total stone production is very small.

Lime production in 1986 was approximately 346,000 tonnes (1987 Ontario Mineral Score) and was manufactured by General Chemical Canada Ltd.

Almost all of the production reported for the limestone industries of the district was derived from quarry properties and/or plants in Essex County, most of which was derived from the MacGregor Quarry (CH–1) currently operated by General Chemical Canada Ltd. and under lease agreements by Amherst Quarries (1969) Ltd. and Kennette Contracting Ltd.

Building stone production in 1986 is reported to be in the order of 300 tonnes and is derived from the Amherstburg Quarry (CH–3). The stone is hand split and trimmed by a local stone mason from Harrow, Ontario.

## CH–1 GENERAL CHEMICAL CANADA LTD. — MACGREGOR QUARRY

### LOCATION AND OWNERSHIP

This large quarry is located in Lots 8, 9 and 10, Concessions 6 and 7, Anderdon Township, Essex County, 10 km northeast of Amherstburg (Figure CH–1–1). In June, 1986 the pit occupied about 77 ha of a total licensed area of 269 ha.

General Chemical Canada Ltd. changed its name from Allied Chemical Canada Ltd. in 1986, and is the operator of a chemical plant at Amherstburg that has been supplied for many years by local quarries. The MacGregor Quarry was opened in 1970 and is currently operated by General Chemical for chemical stone and, under lease agreements by Amherst Quarries (1969) Ltd. and Kennette Contracting Ltd., for aggregate stone.

The quarry is presently being worked to the south where several years of limestone reserves remain. After this area is extracted, a reserve east of the concession road will be tapped.

### GEOLOGY

The MacGregor Quarry exposes 32 m of the Middle Devonian Lucas Formation (Figure CH–1–2). The upper

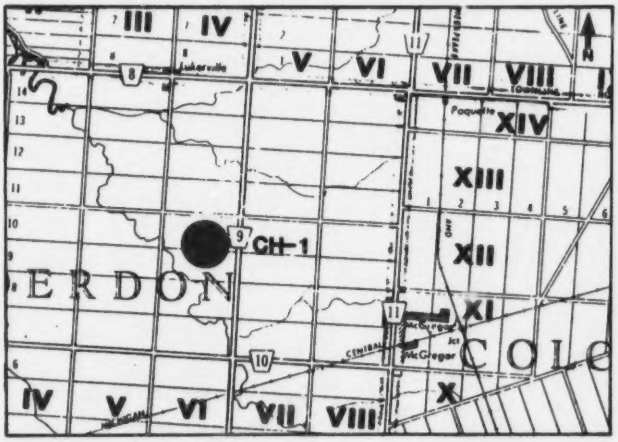
III
IV
V
VI
VII
VIII
N
XIV
XIII
XII
XI
X
8
9
10
11
CH-1
ERDON
COLC
IV
V
VI
VII
VIII
McGregor

Figure CH-1-1. LOCATION MAP FOR MACGREGOR QUARRY.

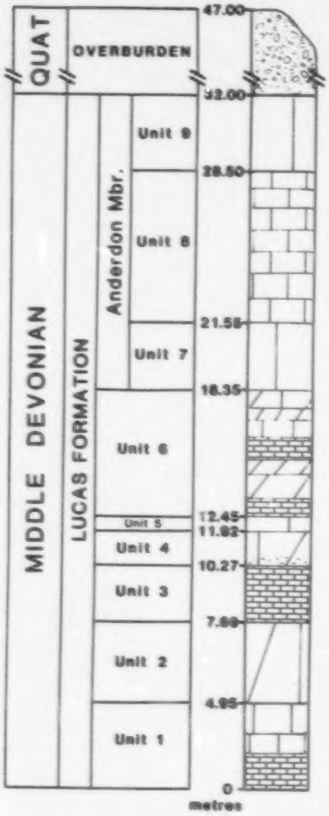

Figure CH-1-2. STRATIGRAPHIC COLUMN FOR MACGREGOR QUARRY.

13.65 m represents the Anderdon Member of the Lucas Formation, which has been shown by drilling to be elliptical in shape and elongated north-south and thins to 6 m at the eastern and western quarry limits. The Anderdon Member consists mainly of a pure, microcrystalline to very fine-crystalline, vuggy limestone with zones of interbedded rubbly limestone, and mottled and banded limestone. The lowermost bed contains abundant stromatoporoids. The balance of the formation consists of interbedded units of fossiliferous limestones, banded limestones and dolostones, dolomitic limestones, microcrystalline limestones and rare calcareous sandstone beds. Scattered zones are very fossiliferous, while others are barren.

A thin cap of dolomitic limestone of the overlying Dundee Formation has been encountered in parts of the quarry, and is known to reach 11 m in thickness in the future quarry site east of the concession road.

Overburden is thick, 12 to 15 m of a gritty clay-silt till overlies the bedrock surface.

## Geological Section

*Thickness*

*UNIT 9 Lucas Formation, Anderdon Member* *3.5m*

Limestone: cream to very light grey, weathers cream; subcrystalline to very fine crystalline; one massive bed; very abundant calcite crystals in vugs and patches; stylolites common in places; some fossil debris present; lower contact is sharp and irregular.

*UNIT 8 Lucas Formation, Anderdon Member* *6.95m*

Interbedded limestones (lithographic, mottled, and banded): cream, blue-grey, tan; weathers buff-grey; sub- to fine-crystalline; thick bedded with sharp, welded and irregular contacts, some are stylolitic; rare sedimentary features (rip-ups and flame structures); banding is present in some beds; calcite crystals present in vugs in mottled zones; fossiliferous with abundant rugose corals present 2.5 m from top of unit, rare gastropods and fossil fragments; beds are very porous and vuggy; lower contact is covered.

*UNIT 7 Lucas Formation, Anderdon Member* *3.2m*

Limestone: light grey to light brown, weathers buff; fine to medium crystalline; one massive bed; appears sandy in places; unit stands out as a distinct resistant bed; fossiliferous, with very abundant stromatoporoids (up to 35 cm long) occur with well preserved internal structures; some stromatoporoids are surrounded by sand and silt laminae; abundant rugose corals also occur; lower contact is sharp.

*UNIT 6 Lucas Formation* *5.9m*

Interbedded limestones and dolostones: medium grey to brown buff, weathers grey to brown; fine crystalline; medium to thick bedded, contacts are sharp and welded, and sometimes stylolitic; these interbedded lithologies are similar to Units 2 and 4; abundant fossil debris is present in the more porous lithologies; a 45 cm thick, massive, fine-crystalline, grey dolomitic limestone bed caps this unit and contains abundant bituminous partings; lower contact is sharp and stylolitic.

*UNIT 5 Lucas Formation* *0.53m*

Limestone (lithographic): grey, weathers light to dark grey; micro-to subcrystalline; one massive bed; somewhat mottled (light to dark grey) separated by stylolites; lower contact is sharp, stylolitic, welded, and very irregular.

*UNIT 4 Lucas Formation* *1.65m*

Limestone, with sandstone and dolomitic limestone: tan, weathers buff-brown; fine crystalline; one massive unit; lower 35 cm is a calcareous sandstone, fine grained, with well developed stromatoporoids (containing grey laminations) that appear to be surrounded by sand; the sandstone grades up into a laminated limestone, which in turn is overlain by a porous, rubbly dolomitic limestone (similar to Unit 2); the upper 10-15 cm contains pelletoid material and is not porous; fossiliferous with abundant fossil fragments and crinoids present, and scattered rugose corals; sharp lower contact.

*Unit 3 Lucas Formation* *2.58m*

Limestone: tan, weathers buff; fine crystalline; medium bedded (approximately 15 cm); lightly banded, some beds are almost microcrystalline; calcite mineralization present in small vugs; some fossil molds; sharp, irregular and welded lower contact.

*UNIT 2 Lucas Formation* *2.74m*

Dolomitic limestone: light brown, weathers medium dark brown; fine crystalline; one massive bed; very porous with patches of calcite mineralization in vugs; fossiliferous, with abundant fossil debris and reefal; some iron staining; lower contact is sharp and welded.

*UNIT 1 Lucas Formation* *4.95m*

Limestone: brown and dark brown bands, weathers brown; fine crystalline; medium to thick bedded, sharp contacts, irregular bedding with thin bituminous partings; lower 0.5 m is banded with bituminous partings; petroliferous odor; thicker beds are microcrystalline and contain rip-up clasts; calcite crystals present in vugs; fossiliferous, with abundant brachiopods in lenses.

*Total thickness* *32.0m*

## CHEMICAL ANALYSES*

| | Components in Percent | | |
|---|---|---|---|
| **Unit** | **8** | **7** | **6 (top)** |
| **$SiO_2$** | 0.29 | 0.31 | 0.37 |
| **$Al_2O_3$** | 0.25 | 0.49 | 0.82 |
| **$Fe_2O_3$** | 0.26 | 0.20 | 0.29 |
| **MgO** | 0.26 | 0.51 | 16.0 |
| **CaO** | 55.2 | 54.9 | 37.3 |
| **L.O.I.** | 43.6 | 43.5 | 45.9 |
| **Total** | 99.86 | 99.91 | 100.68 |
| **$CO_2$** | 41.1 | 43.8 | 44.7 |

* *After Hewitt and Vos 1972, p.66.*

Photo CH-1-1. CONTACT BETWEEN UNITS 2 AND 3, LUCAS FORMATION; MACGREGOR QUARRY.

## QUARRY OPERATION AND PROCESSING

General Chemical Canada Ltd. works the upper (Anderdon Member) bench at the south end of the quarry, while Amherst Quarries (1969) Ltd. works the lower benches at the north end. Kennette Contracting Ltd. operates a screening and washing plant on the floor of the upper bench.

After the overburden has been removed by a subcontractor, General Chemical drills blast holes in the limestone with an Ingersoll-Rand Drillmaster. Holes of 17 cm diameter are drilled to 1 m below grade on a 6 m x 7 m pattern, and blasted with M210 slurry powder in groups of 15 to 25 holes.

A portable crushing and screening plant is located close to the working face. Two Cat 992 loaders with 10 yd. buckets load the 44 in. x 48 in. primary jaw crusher directly from the face.

Discharge from the crusher passes over two 7 ft. x 20 ft. vibrating screens, and the −6 in. + 1 in. lump product is hauled 10 km to the chemical plant in Amherstburg in 40-tonne loads by a fleet of six Mack highway trucks pulling pup trailers. Weigh scale, administration office and maintenance shops are all located on the north side of the quarry. With fines removed, the stone grades 89–94% $CaCO_3$.

At the north end of the quarry, drilling is accomplished using a Gardner-Denver diesel quarry drill. A 42 in. x 36 in. jaw crusher is fed by three 35-ton Caterpillar 980 trucks which are loaded by two front-end loaders. Secondary crushing is done by two shorthead cone crushers: a 4 1/2 ft. Nordberg and a 3 1/2 ft. Hewitt-Robins, in closed circuit with three vibrating screens which provide a variety of stone products. Kennette Contracting works under a subcontract from Amherst Quarries to produce washed aggregate, using −1 in. screenings from the General Chemical plant and a single screen and washing plant.

## PRODUCTS

### General Chemical

Chemical Stone

### Amherst Quarries

Armour Stone
Gabion Stone (6 in.)
Crusher Run
−3/4 in. + 1/2 in.
− 1 1/4 in. + 7/8 in.
−7/8 in.
Granular "A"
Screenings and chips

### Kennette Contracting

3/4 in. Clear

**Photo CH-1-2.**
**SODA ASH AND CALCIUM CHLORIDE PLANTS; MACGREGOR QUARRY.** *(Photo courtesy B.H. Feenstra, Ministry of Northern Development and Mines, London, 1983).*

1/4 in. Clear
Screenings

## REFERENCES

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Koniuszy and Katona, 1981, p.18–27
Uyeno et al., 1982, p.45

## MAPS

Telford and Russell, 1981, OGS Map P.2396

## CH-2 GENERAL CHEMICAL (ALLIED CHEMICAL) QUARRY (ABANDONED)

### LOCATION AND OWNERSHIP

This quarry is located 0.5 km north of Amherstburg (Figure CH-2-1), in Lots 2 and 3, Concession 2, Anderdon Township, Essex County behind the General Chemical plant. The quarry exposes limestone of the Middle Devonian Lucas Formation. Two quarries are located here; one to the north that is now a waste pond for the plant and had previously been operated by Brunner Mond Canada Ltd., and the other abandoned quarry to the south which was operated by General (then Allied) Chemical which exposes 7 m of limestone.

### GEOLOGY

The lower unit of the quarry face is a subcrystalline to very fine- crystalline, thin- to medium-bedded, pelletoidal limestone. The upper 5.9 m consists of the Anderdon Member of the Lucas Formation of which the lower 0.45 m is a calcareous sandstone, part of the sandy limestone facies of the Anderdon. The rest of the Anderdon is a fine-crystalline, thin-bedded and banded limestone. This abandoned quarry is partially water filled. The area is transected by an anticline (trending northwest).

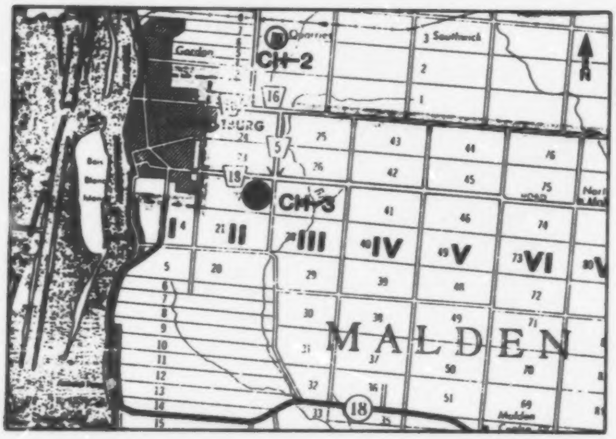


**Figure CH-2-1. LOCATION MAP FOR GENERAL CHEMICAL (ALLIED CHEMICAL) QUARRY.**

The infilled Brunner Mond Quarry exposed a different section (Hewitt, 1960, p. 164–167). Stone from this quarry had been used to provide blocks for the Sault locks at Sault Ste. Marie (Photo CH-2-1).

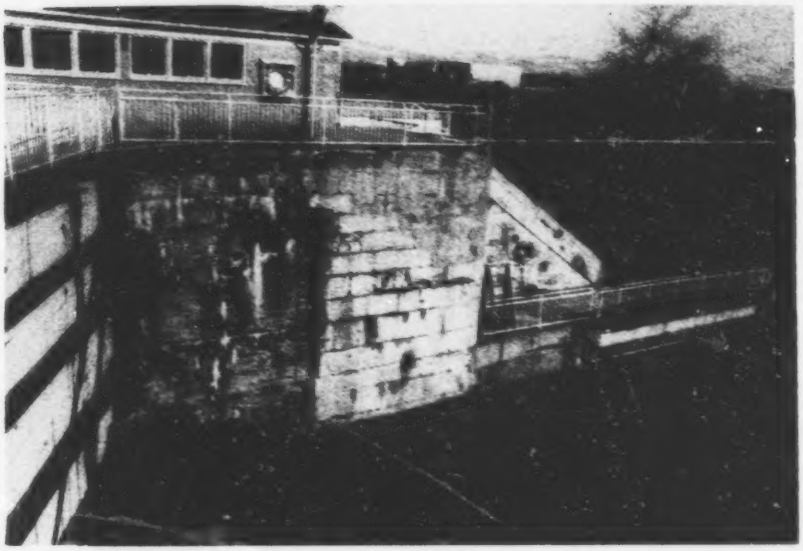
### Geological Section

*Thickness*

*UNIT 3 Lucas Formation, Anderdon Member* *5.45m*

Limestone: brown-grey, weathers brown; fine crystalline; medium bedded (10 to 15 cm), thickens upward, contacts are transitional to somewhat sharp and irregular; banded in the middle of the unit with light and dark grey colours (1 m thick); very vuggy in the upper 1.5 m with calcite crystals filling vugs (vugs are up to 15 cm in diameter); the upper beds become massive, porous, possess a petroliferous odor, and are also dolomitic; the lower contact is sharp.

**Photo CH-2-1.**
**LOCKS AT SAULT STE. MARIE BUILT WITH LIMESTONE BLOCKS OF THE LUCAS FORMATION FROM THE BRUNNER MOND QUARRY, 1887–1895.** *(Photo courtesy B.H. Feenstra, Ministry of Northern Development and Mines, London).*



*UNIT 2 Lucas Formation, Anderdon Member 0.45m*

Calcareous sandstone: light grey to tan, weathers buff; fine to medium grained; one massive bed; contains thin lenses of microcrystalline buff limestones; some mottled grey patches; lower contact is sharp.

*Unit 1 Lucas Formation 1.10m*

Limestone: medium grey to medium brown; weathers grey-brown; microcrystalline to subcrystalline; thin to medium bedded (10 to 15 cm at base, 3 cm at top), contacts are sharp and slightly irregular; lower 0.6 m have a pelletoid appearance (1 to 3 mm in diameter); upper 0.50 m is more subcrystalline.

*Total thickness 7.00m*

## REFERENCES

Caley, 1946, p.32
Diffendal, 1971, p.19–20
Goudge, 1938, p.217–219
Hewitt, 1960, p.164–167
Hewitt, 1964a, p.67
Uyeno et al., 1982, p.14, 44–45

## MAPS

Caley, 1945a, GSC Map 828A
Telford and Russell, 1981, OGS Map P. 2396

## CH-3 AMHERST QUARRIES (1969) LTD. — AMHERSTBURG QUARRY

### LOCATION AND OWNERSHIP

This large quarry is located 2 km east of Amherstburg in Lots 21 and 22, Concession 2, Malden Township, Essex County (Figure CH-3-1), and has been operating since

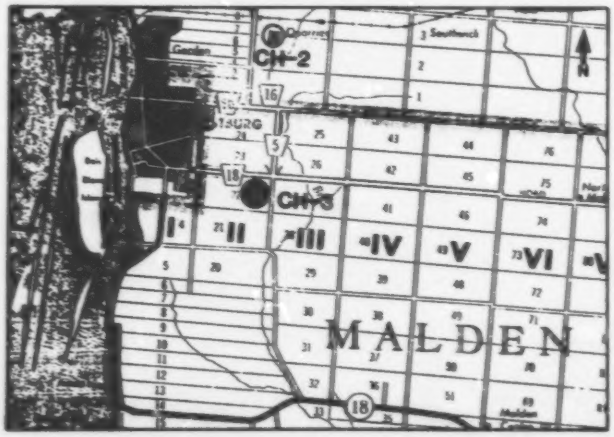


**Figure CH-3-1. LOCATION MAP FOR AMHERSTBURG QUARRY.**

1935. Initially operated by Industrial Construction Company Limited in the 1930s, this quarry was once the sole source of crushed aggregate products for Amherst Quarries. The Amherstburg Quarry now supplies only 20% of the company's annual production, the rest being obtained from the MacGregor Quarry (CH–1) under an operating agreement with General Chemical Canada Limited.

The quarry is operated on three lifts and covers an area of about 14 ha. Over a half of the licensed area is still available for quarrying to the south, and minor expansion is possible to the west. To the east and north, however, the quarry is confined by roads.

## GEOLOGY

At the north end of the quarry, about 10 m of overburden overlies Middle Devonian Detroit River Group limestones, the Amherstburg and Lucas Formations making up 24.40 m and 25.75 m of the quarry face, respectively (Figure CH–3–2). The Amherstburg Formation consists of zones of bituminous dolostone and oolitic, bioclastic and coralgal limestones which occur in varying amounts. The Lucas Formation is similar to the Amherstburg, but becomes a more massive, bioclastic limestone (biostromal) at the top. The section spans the Amherstburg/Lucas Formation boundary, but the precise contact cannot be easily identified.

### Geological Section

| | Thickness |
|---|---|
| *UNIT 8 Lucas Formation* | *2.20m* |

**Biostromal limestone: tan–buff, weathers yellow–buff; fine crystalline; massive bedded; base of unit contains coralgal debris, overlain by cone– shaped stromatoporoids (up to 20 cm high), which in turn is overlain by a crinoidal-rich debris zone; fossiliferous, with abundant coralgal debris, stromatoporoids, rugose corals (at top), and rare bryozoans· lower contact is gradational to unfossiliferous limestone.**

| | |
|---|---|
| *UNIT 7 Lucas Formation* | *4.65m* |

**Limestone: light brown to tan (medium brown in porous zones), weathers buff; fine crystalline; one massive bed; calcite crystals in porous zones; porous zone (1 m thick) occurs 1.5 m above the base; faint laminations also present; rare fractures filled with calcite; lower contact is sharp.**

| | |
|---|---|
| *UNIT 6 Lucas Formation* | *10.50m* |

**Interbedded banded limestones and dolostones: brown to tan, weathers brown; subcrystalline to fine crystalline; massive bedded (average 1 to 2 m), contacts are sharp, irregular, stylolitic and some are bituminous; coralgal debris abundant in some bands; scattered prominent bituminous layers that are recessive; this unit is similar to Units 4 and 5, but is more banded and lacks the vuggy zones and mineralization; lower contact is very sharp and stylolitic.**

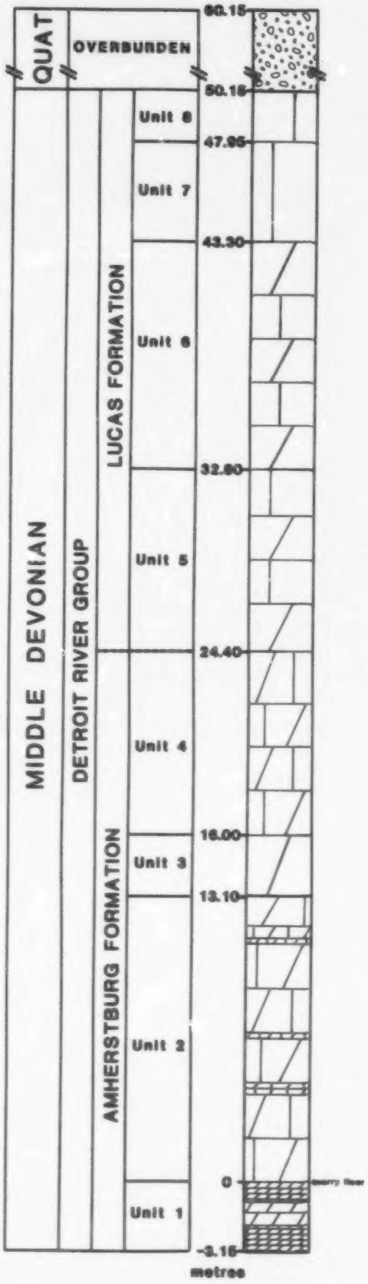


Figure CH–3–2. STRATIGRAPHIC COLUMN FOR AMHERSTBURG QUARRY.

*UNIT 5 Lucas Formation 8.40m*

Interbedded limestones and dolostones: tan, cream to buff, weathers same; very fine to fine crystalline; massive bedded with sharp contacts, very irregular, often stylolitic, rip-up clasts; calcite and celestite mineralization in vugs; oolitic limestone (0.75 m thick) present at base of unit; calcarenite beds (up to 3 cm thick) are also present; lower contact is gradational.

*UNIT 4 Amherstburg Formation 8.40m*

Calcareous dolostone: dark brown, weathers brown to tan; subcrystalline to fine crystalline; massive bedded and banded; calcite mineralization occur in vugs as a band 8 m above the base; celestite also occurs in vugs 5.2 m above the base, vugs range from 5 to 10 cm in diameter; sparsely fossiliferous, with scattered stromatoporoids, some replaced by chert (some of this chert is leached); lower contact is base of lift #2.

*UNIT 3 Amherstburg Formation 2.90m*

Dolostone: medium brown, weathers buff; fine to coarse crystalline; massive bedded, contacts are sharp, slightly irregular, some have bituminous partings; calcite crystals and other exotic minerals occur in vugs; this unit is marked by 2 to 3 cm thick dolomitic calcarenites and massive dolostones which display pinch and swell features and are very irregular; unit stands out as a prominent ledge; lower contact is sharp and slightly irregular.

*UNIT 2 Amherstburg Formation 9.95m*

Calcareous dolostone: tan to grey, weathers buff-grey; fine to medium crystalline; mainly massive bedded (approximately 1 m thick), with some minor thin beds (up to 5 cm), contacts are sharp and irregular, some are stylolitic or bituminous; calcite, celestite, and exotic crystals occur within vugs (up to 7 cm in diameter); iron staining present; banding and laminations are very prominent; lower contact is covered.

*UNIT 1 Amherstburg Formation 3.15m*

Bituminous dolostone: dark brown to black, weathers medium dark brown to black; medium crystalline; thin to medium bedded (quite variable, 3 to 50 cm), contacts are sharp, very irregular and sometimes bituminous; large crystals of calcite and celestite occur in vugs (up to 15 cm); fossiliferous, with abundant coralgal debris and bryozoa and scattered crinoidal debris; unit is very banded and laminated; slight petroliferous odor present; rare vertical fractures filled with calcite.

*Total thickness 50.15m*

## CHEMICAL ANALYSES - UNITS 4 AND 5*

Components in Percent

| | | | |
|---|---|---|---|
| $SiO_2$ | 0.66 | $P_2O_5$ | 0.02 |
| $Al_2O_3$ | 0.12 | $SO_3$ | 4.16 |
| $Fe_2O_3$ | 0.10 | SO | 5.12 |
| MgO | 18.2 | L.O.I. | 42.9 |
| CaO | 28.8 | Total | 100.1 |

* *After Hewitt and Vos, 1972, p.66.*

## QUARRY OPERATION

The quarry is worked by drilling and blasting, using an RD40 Gardner–Denver diesel drill. Secondary breaking of the shot rock is done with a Dominion dropball. The stone is loaded at the face into two 40–ton quarry trucks by front–end loader and delivered to the processing plant.

## PROCESSING

The delivered stone is dumped into a 48 in. primary impact crusher. A 42 in. belt conveys the stone to a 36–inch Hewitt–Robins secondary impact crusher. Screening is done in two stages, one of which is in closed circuit with the secondary crusher. There is no washing plant.

## PRODUCTS

Armour Stone

**Photo CH-3-1.**
**QUARRY OVERVIEW, 1983; AMHERSTBURG QUARRY.**
*(Photo courtesy B.H. Feenstra, Ministry of Northern Development and Mines, London).*

Gabion Stone
2 1/2 in. Crusher Run
7/8 in. Crusher Run
3/4 in. Clear
Screenings
−1 1/4 in. + 7/8 in. Stone
−3/4 in. + 1/2 in. Stone

The stone generally does not meet specifications for asphalt or concrete stone.

Building stone blocks and ashlar from 10 cm to 20 cm thick are hand split and trimmed by a local stone mason from Harrow. Production amounts to less than 300 tonnes per year.

### REFERENCES

Caley, 1946, p.33–34
Goudge, 1938, p.219
Hewitt, 1960, p.168
Hewitt, 1964a, p.67–69
Hewitt and Vos, 1972, p.66
Koniuszy and Katona, 1981, p.28–37

### MAPS

Caley, 1945a, GSC Map 828A
Telford and Russell, 1981, OGS Map P.2396

## CH-4 670026 ONTARIO LIMITED — PELEE ISLAND QUARRY

### LOCATION AND OWNERSHIP

This is the only active operation on Pelee Island and is located in Lots 1 and 2, Concession Registered Plan 35, Pelee Island Township, Essex County (Figure CH-4-1). The quarry was acquired in 1986 by 670026 Ontario Limited from Marentette Bros. Ltd. Approximately 10 ha have been licensed for extraction, 9 ha of which have been disturbed on a single lift of 6 m.

The principal product is armour stone, comprising about two-thirds of the 1986 production. The armour stone is primarily supplied to the local conservation authority and used for shoreline protection and rehabilitation programs. The quarry is located 150 m from the shore of Lake Erie and would be ideal for supplying armour stone for construction of a local marine facility.

The Pelee Island Quarry also supplies crushed stone products for local construction projects.

### GEOLOGY

The Pelee Island Quarry exposes 6.0 m of limestone from the Dundee Formation (Middle Devonian). The lower 5 m are medium crystalline, massive, very fossiliferous, with a strong petroliferous odor and scattered oil seeps. The top 1 m of the unit is fine to medium crystalline, thin bedded and fossiliferous. Across the road to the south, a water-filled abandoned quarry exposes 1.9 m of the upper unit described in the operating quarry. It is a thin-bedded, cherty, very fossiliferous pelletoid limestone.

Overburden is thin to nil in thickness.

### Geological Section

| | | *Thickness* |
|---|---|---|
| *UNIT 2* | *Dundee Formation* | *1.0m* |
| | **Limestone: brown, weathers buff; fine to medium crystalline; thin bedded (2 to 5 cm), contacts are sharp and planar; fossiliferous with abundant corals and brachiopods; lower contact is sharp and appears to scour into the lower unit.** | |
| *UNIT 1* | *Dundee Formation* | *5.0m* |
| | **Limestone: brown, weathers buff to light brown; medium crystalline; thick bedded; chert nodules present which replace corals; calcite crystals present; very fossiliferous with abundant bryozoans, corals, brachiopods, crinoids, rugose, fragments and pellets; very strong petroliferous odor, with some oil seepage occurrence; darker argillaceous laminations are present; coarser grained zones containing pelletoid material are also present.** | |
| *Total thickness* | | *6.0m* |

### QUARRY OPERATION

The quarry normally operates during the period May to November. Water seepage into the quarry is minimal (current quarry floor is below lake level).

Drilling and blasting is performed by the company, while crushing is contracted. A drill pattern of 1.8 m x

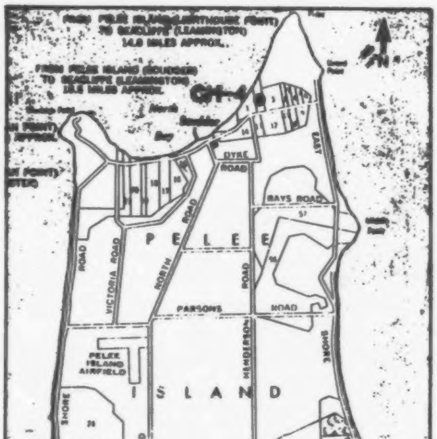


**Figure CH-4-1. LOCATION MAP FOR PELEE ISLAND QUARRY.**

1.8 m with 63.5 mm diameter blast holes is currently used. Blast holes are loaded with a decoupled charge of Xactex explosive to a height of about 3.4 m. Decoupling is achieved by using a packaged explosive of considerably less diameter than the blast hole (charge does not touch blast hole surface). Xactex is a semi-gelatin explosive bound in a rigid paper tube 15 mm in diameter and 600 mm in length, used primarily for presplit or preshearing blasting applications. The Xactex explosive provides a high velocity, high pressure detonation but, when decoupled, breaks the limestone structure in tension eliminating excessive shattering and fragmentation. A 1 m gap in the blast hole is allowed above the Xactex charge followed by a plug and crushed stone stemming (2 m) to collar. This blast design results in a low bulk density charge relative to the drill pattern, producing the desired size of armour stone.

## PRODUCTS

Armour Stone

## REFERENCES

Goudge, 1938, p.221
Koniuszy and Katona, 1981, p.38–45

## MAPS

Telford and Russell, 1981, OGS Map P. 2396

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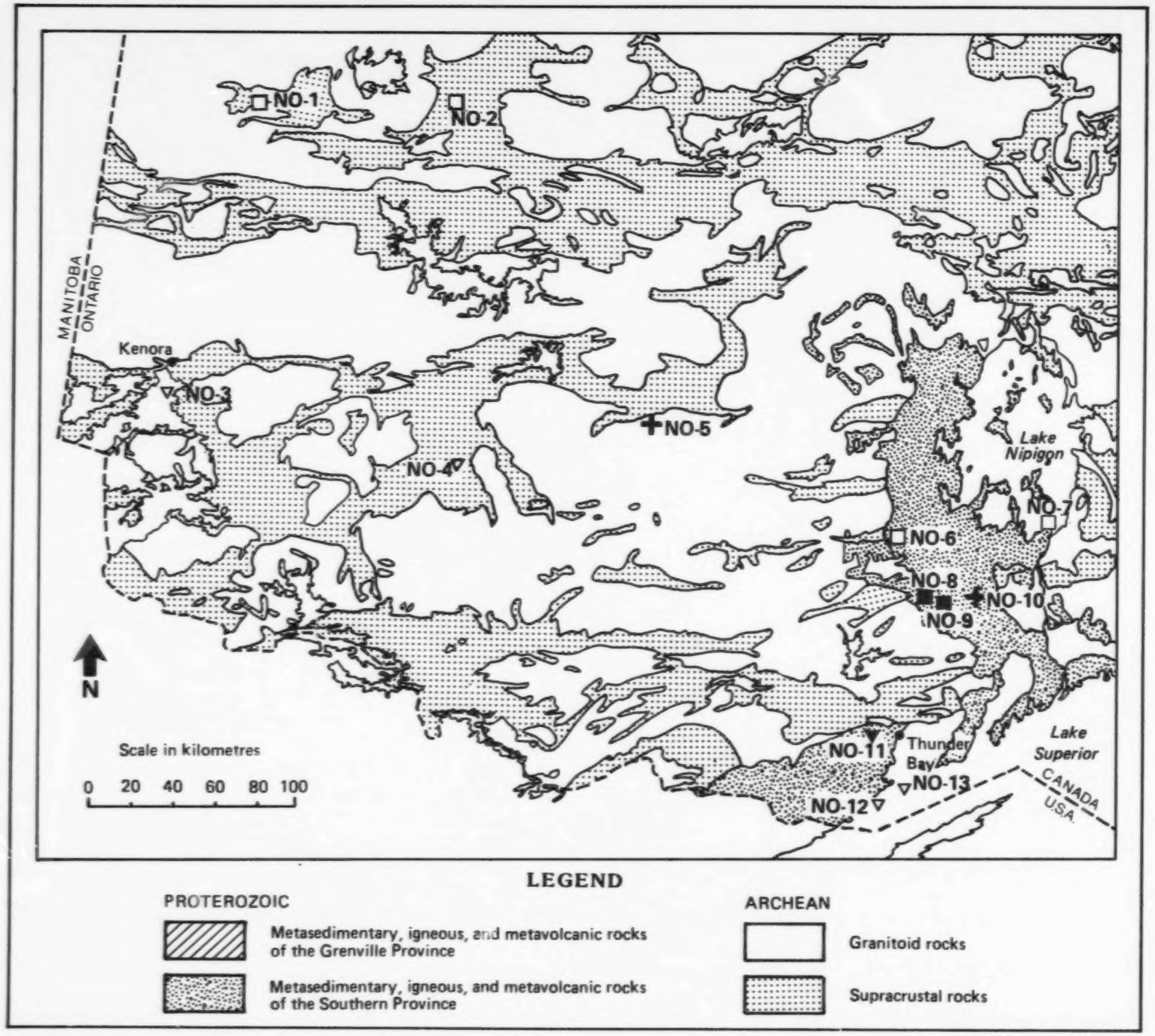
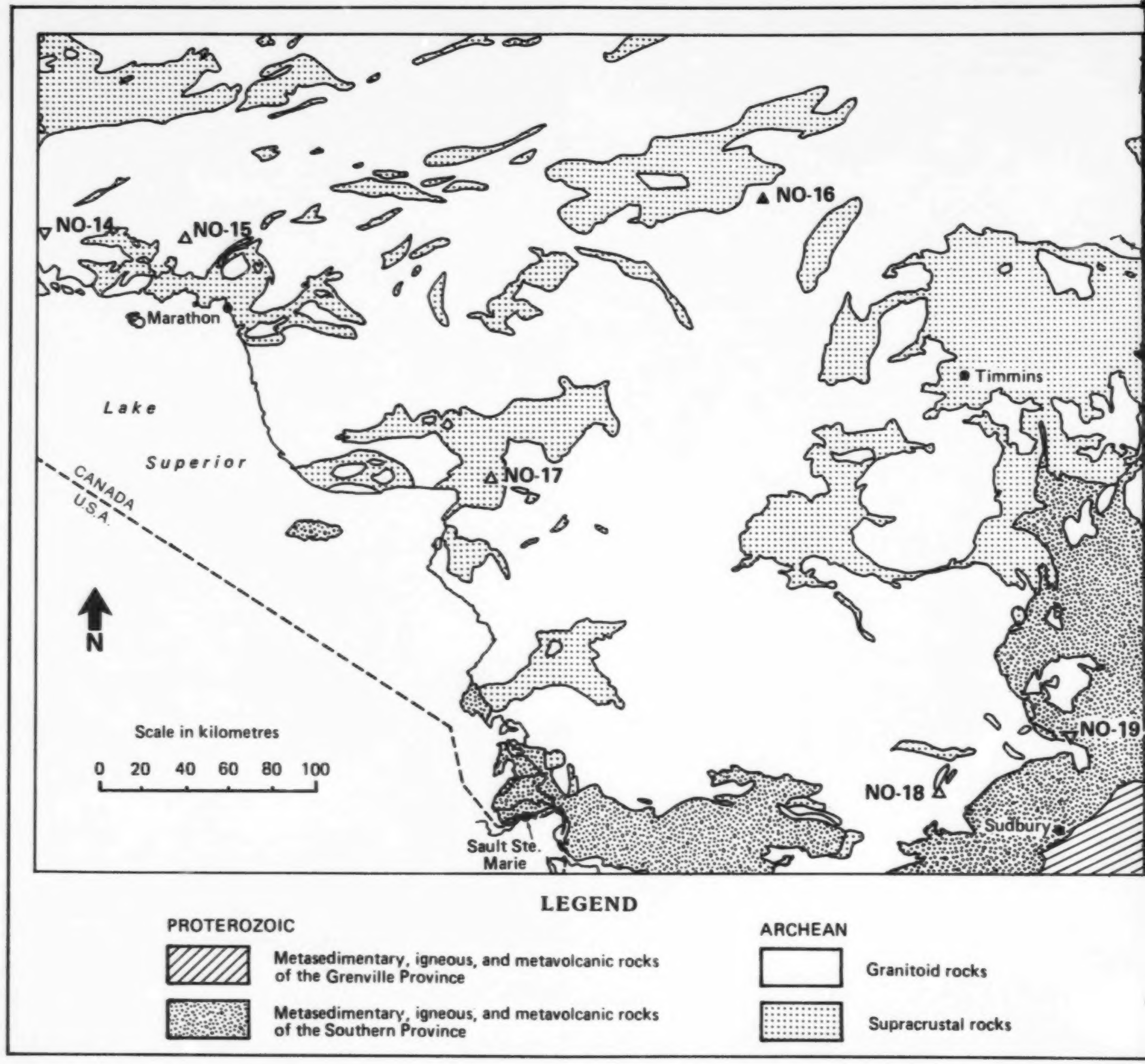


NO-1
NO-2
MANITOBA
ONTARIO
Kenora
NO-3
NO-4
NO-5
Lake Nipigon
NO-6
NO-7
NO-8
NO-9
NO-10
NO-11
Thunder Bay
NO-12
NO-13
Lake Superior
CANADA
USA
N
Scale in kilometres
0 20 40 60 80 100
LEGEND
PROTEROZOIC
Metasedimentary, igneous, and metavolcanic rocks of the Grenville Province
Metasedimentary, igneous, and metavolcanic rocks of the Southern Province
ARCHEAN
Granitoid rocks
Supracrustal rocks

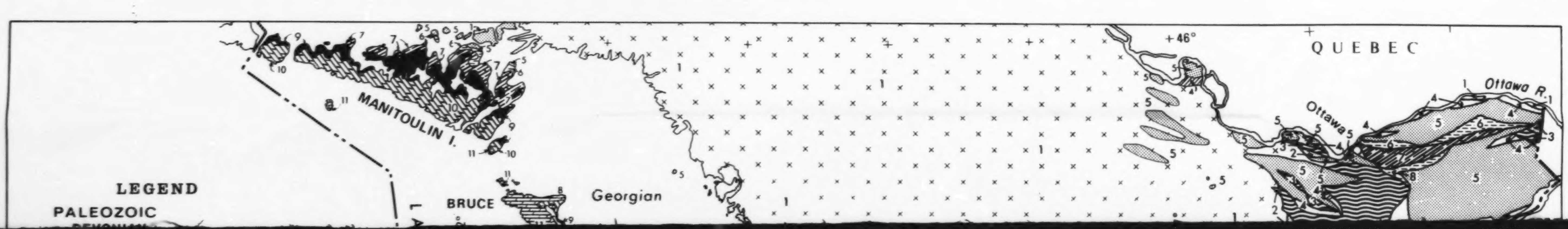
Figure 2.1. CARBONATE DEPOSITS OF THE CANADIAN SHIELD — NORTHWESTERN ONTARIO.



NO-14
NO-15
NO-16
Marathon
Timmins
Lake Superior
CANADA
U.S.A.
NO-17
N
Scale in kilometres
0 20 40 60 80 100
NO-18
NO-19
Sault Ste. Marie
Sudbury
LEGEND
PROTEROZOIC
Metasedimentary, igneous, and metavolcanic rocks of the Grenville Province
Metasedimentary, igneous, and metavolcanic rocks of the Southern Province
ARCHEAN
Granitoid rocks
Supracrustal rocks

Figure 2.3. CARBONATE DEPOSITS OF THE CANADIAN SHIELD — NORTHEASTERN ONTARIO.

Figure



MANITOULIN I.
BRUCE
Georgian
+46°
QUEBEC
Ottawa R.
Ottawa
LEGEND
PALEOZOIC

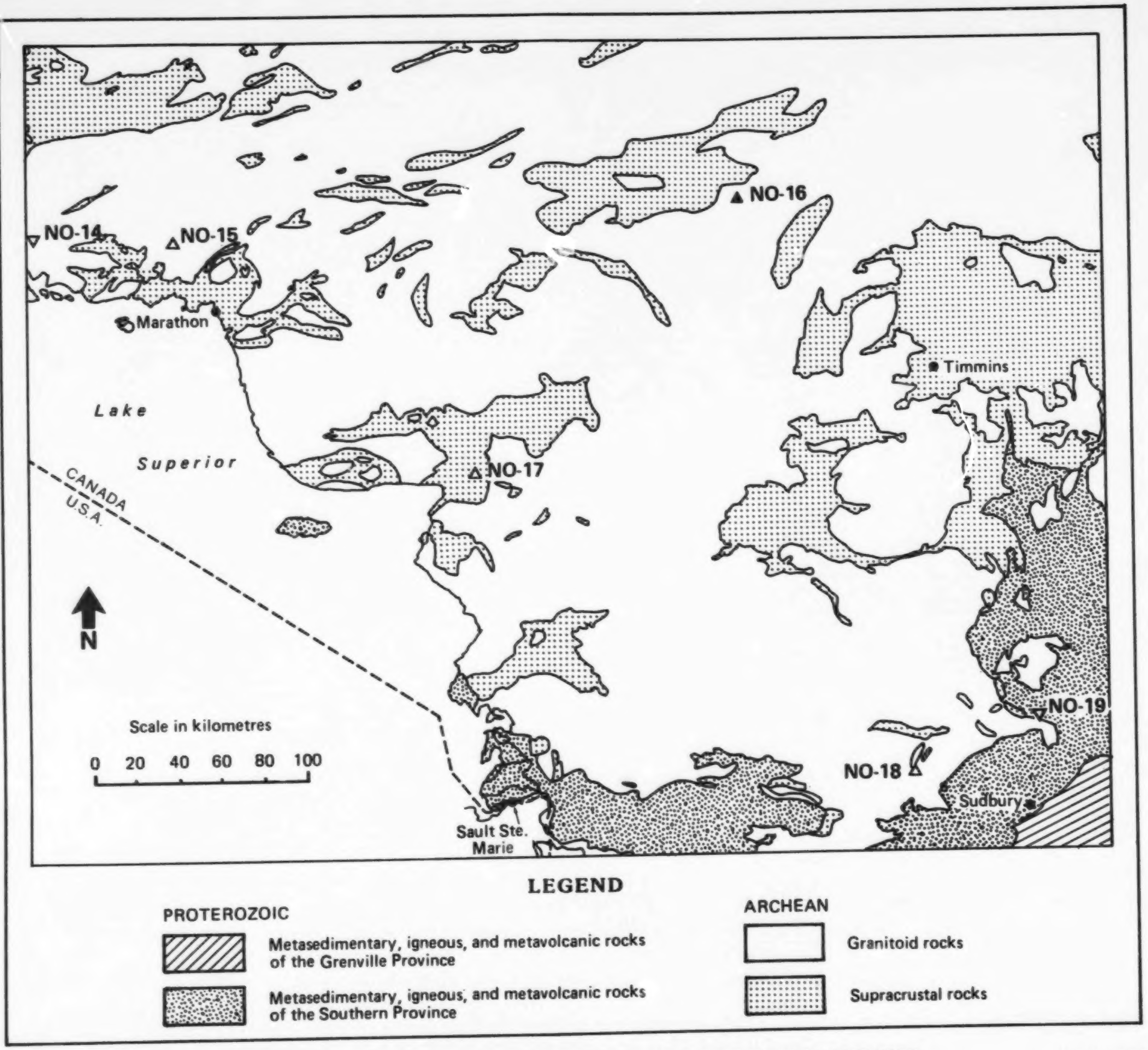

NO-14
NO-15
NO-16
Marathon
Timmins
Lake
Superior
CANADA
U.S.A.
NO-17
N
NO-19
NO-18
Sudbury
Sault Ste. Marie
Scale in kilometres
0 20 40 60 80 100
LEGEND
PROTEROZOIC
Metasedimentary, igneous, and metavolcanic rocks of the Grenville Province
Metasedimentary, igneous, and metavolcanic rocks of the Southern Province
ARCHEAN
Granitoid rocks
Supracrustal rocks

Figure 2.3. CARBONATE DEPOSITS OF THE CANADIAN SHIELD – NORTHEASTERN ONTARIO.

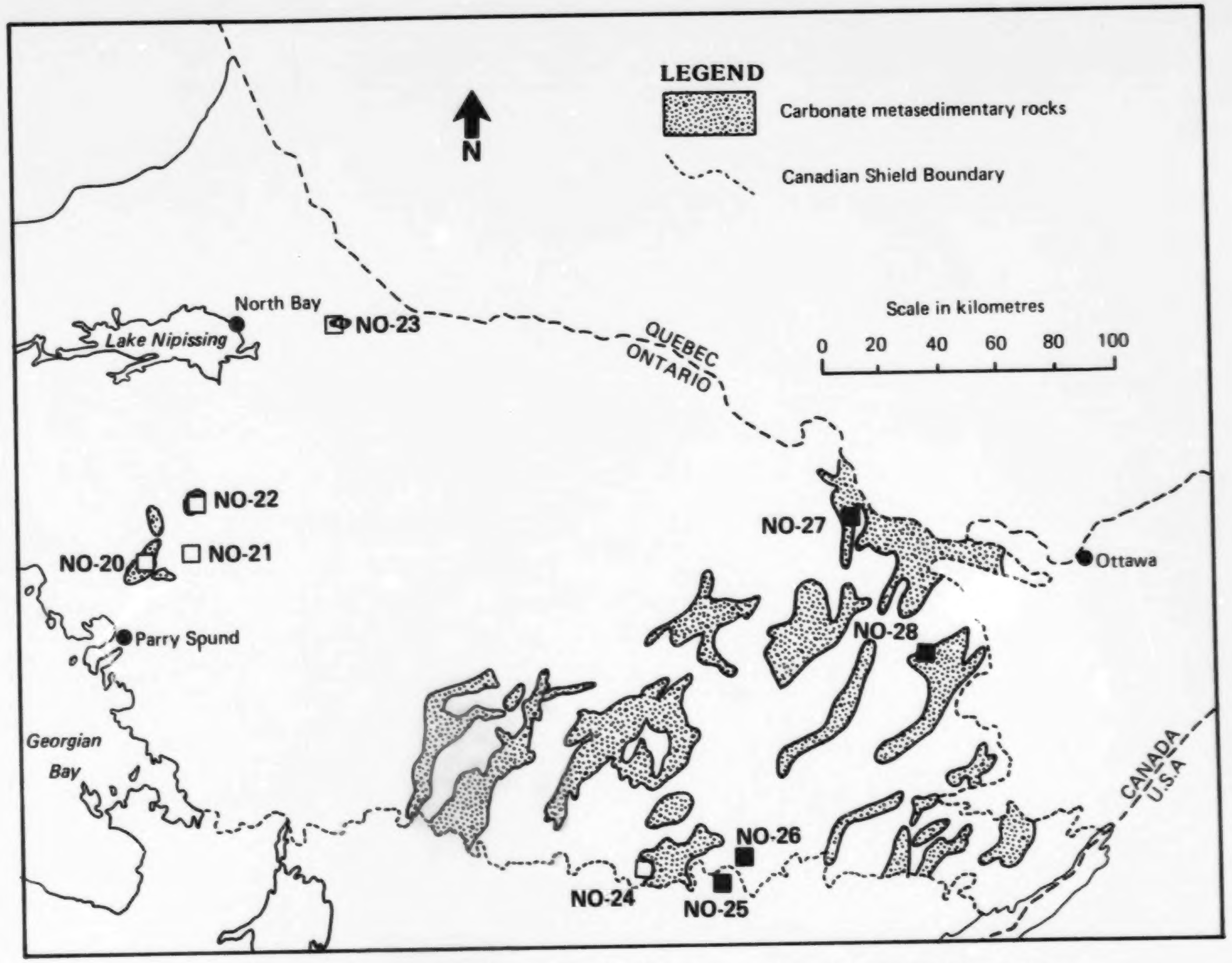

LEGEND
Carbonate metasedimentary rocks
Canadian Shield Boundary
N
North Bay
Lake Nipissing
NO-23
QUEBEC
ONTARIO
Scale in kilometres
0 20 40 60 80 100
NO-22
NO-21
NO-20
NO-27
Ottawa
Parry Spund
NO-28
Georgian
Bay
CANADA
U.S.A.
NO-26
NO-24
NO-25

Figure 2.2. CARBONATE DEPOSITS OF THE CANADIAN SHIELD – SOUTHEASTERN ONTARIO.

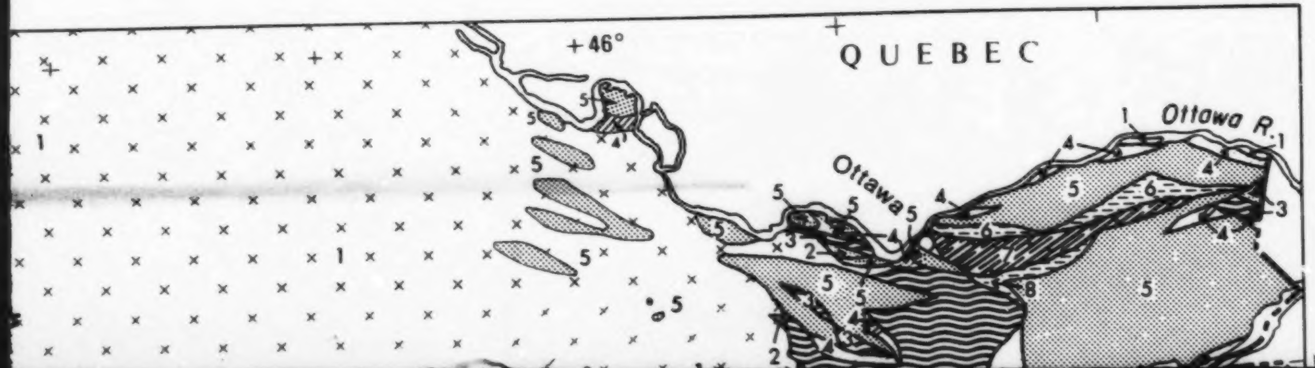
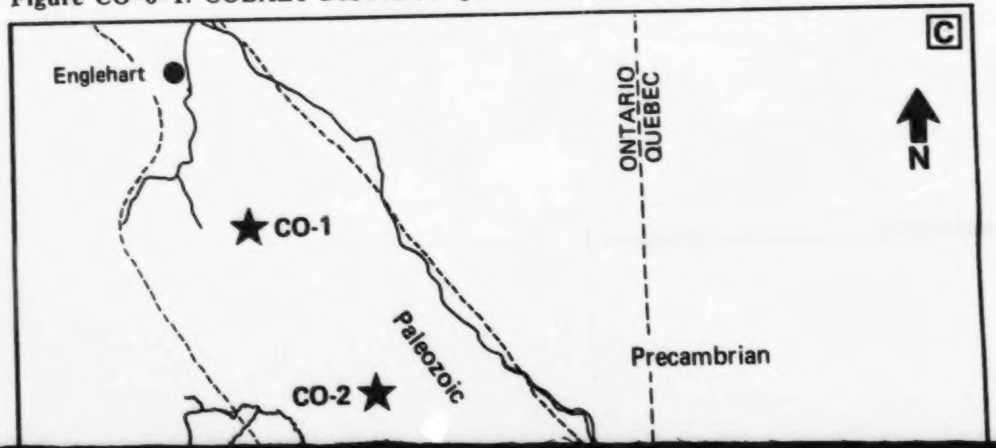
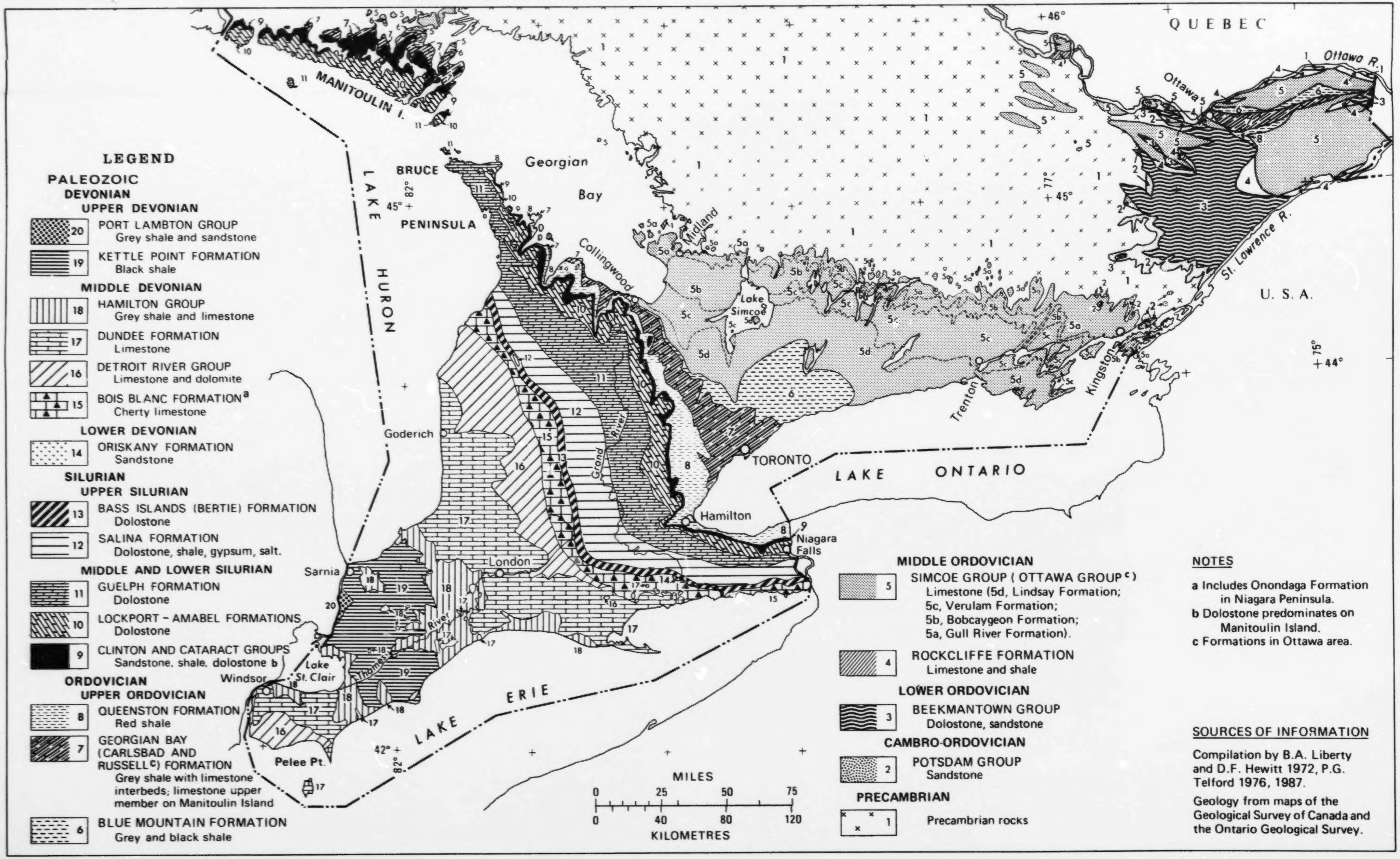

+46°
QUEBEC
Ottawa R.
Ottawa
1
2
3
4
5
6
8

Figure CO–0–1. COBALT DISTRICT QUARRY LOCATION MAP (SEE VOLUME II)


C
Englehart
ONTARIO
QUEBEC
N
CO-1
CO-2
Paleozoic
Precambrian

TYPE OF DEPOSITS

| DORMANT | ACTIVE | |
|---|---|---|
| ☐ | ■ | Marble |
| ▽ | ▼ | Calcite Vein |
| △ | ▲ | Carbonatite Complex |
| ✙ | ✚ | Marl |
| ☆ | ★ | Limestone/Dolostone |


LEGEND
PALEOZOIC
DEVONIAN
UPPER DEVONIAN
20 PORT LAMBTON GROUP Grey shale and sandstone
19 KETTLE POINT FORMATION Black shale
MIDDLE DEVONIAN
18 HAMILTON GROUP Grey shale and limestone
17 DUNDEE FORMATION Limestone
16 DETROIT RIVER GROUP Limestone and dolomite
15 BOIS BLANC FORMATION[a] Cherty limestone
LOWER DEVONIAN
14 ORISKANY FORMATION Sandstone
SILURIAN
UPPER SILURIAN
13 BASS ISLANDS (BERTIE) FORMATION Dolostone
12 SALINA FORMATION Dolostone, shale, gypsum, salt.
MIDDLE AND LOWER SILURIAN
11 GUELPH FORMATION Dolostone
10 LOCKPORT – AMABEL FORMATIONS Dolostone
9 CLINTON AND CATARACT GROUPS Sandstone, shale, dolostone b
ORDOVICIAN
UPPER ORDOVICIAN
8 QUEENSTON FORMATION Red shale
7 GEORGIAN BAY (CARLSBAD AND RUSSELL[c]) FORMATION Grey shale with limestone interbeds; limestone upper member on Manitoulin Island
6 BLUE MOUNTAIN FORMATION Grey and black shale
MIDDLE ORDOVICIAN
5 SIMCOE GROUP ( OTTAWA GROUP[c] ) Limestone (5d, Lindsay Formation; 5c, Verulam Formation; 5b, Bobcaygeon Formation; 5a, Gull River Formation).
4 ROCKCLIFFE FORMATION Limestone and shale
LOWER ORDOVICIAN
3 BEEKMANTOWN GROUP Dolostone, sandstone
CAMBRO-ORDOVICIAN
2 POTSDAM GROUP Sandstone
PRECAMBRIAN
1 Precambrian rocks
QUEBEC
Ottawa R.
Ottawa
St. Lawrence R.
U. S. A.
MANITOULIN I.
LAKE HURON
BRUCE PENINSULA
Georgian Bay
Collingwood
Midland
Lake Simcoe
Goderich
Grand River
TORONTO
LAKE ONTARIO
Hamilton
Niagara Falls
Trenton
Kingston
Sarnia
London
Thames River
Lake St. Clair
Windsor
LAKE ERIE
Pelee Pt.
+46°
+45°
+44°
45° +
42° +
82°
77°
75°
MILES
0 25 50 75
0 40 80 120
KILOMETRES

NOTES

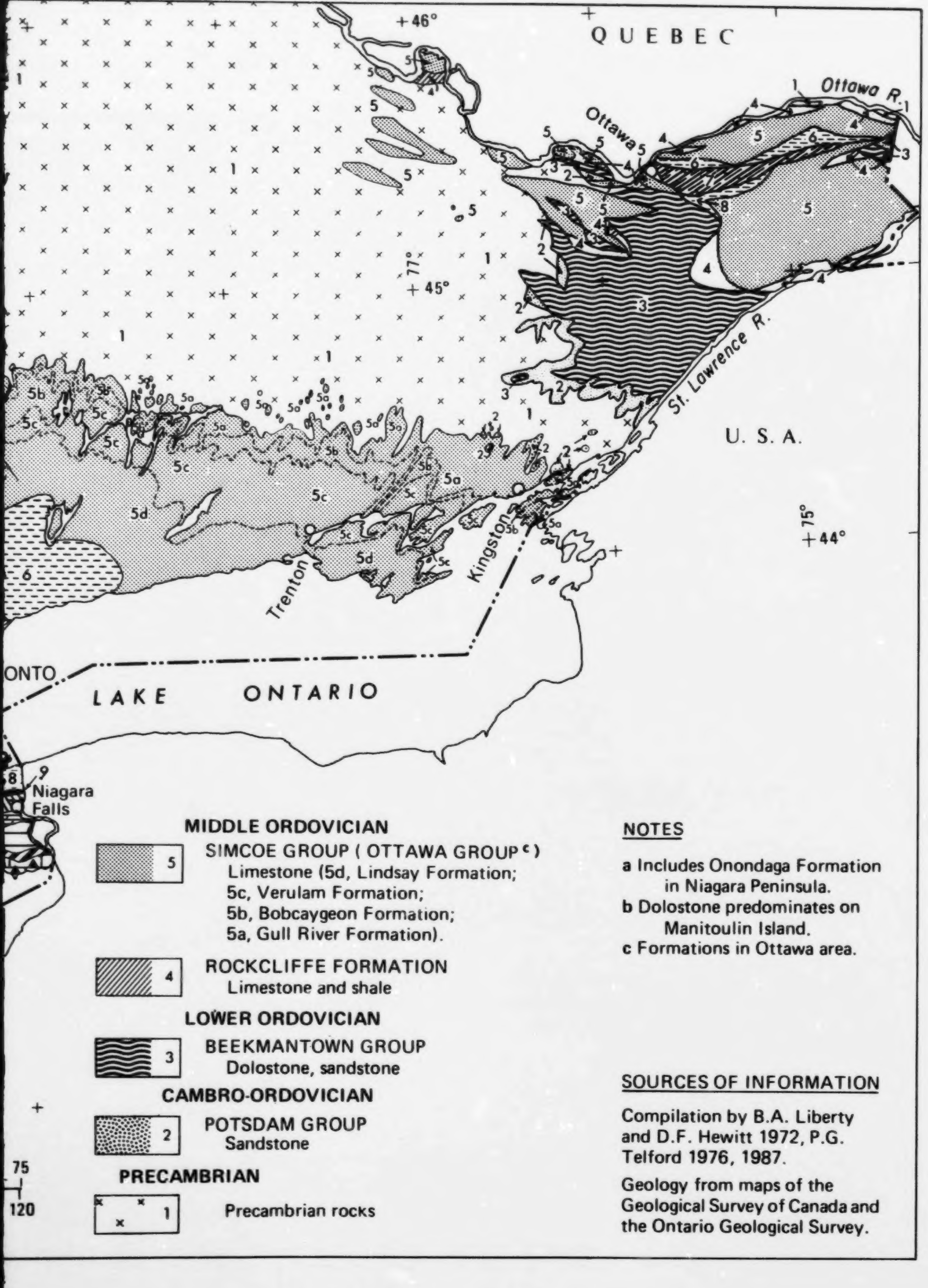
a Includes Onondaga Formation in Niagara Peninsula.
b Dolostone predominates on Manitoulin Island.
c Formations in Ottawa area.

SOURCES OF INFORMATION

Compilation by B.A. Liberty and D.F. Hewitt 1972, P.G. Telford 1976, 1987.

Geology from maps of the Geological Survey of Canada and the Ontario Geological Survey.

Figure 1.1. PALEOZOIC GEOLOGY OF SOUTHERN ONTARIO.


QUEBEC
Ottawa R.
Ottawa
St. Lawrence R.
U. S. A.
Kingston
Trenton
ONTO
LAKE ONTARIO
Niagara Falls
+46°
+45°
+44°
77°
75°
75
120

MIDDLE ORDOVICIAN

5 SIMCOE GROUP ( OTTAWA GROUP [c] )
Limestone (5d, Lindsay Formation;
5c, Verulam Formation;
5b, Bobcaygeon Formation;
5a, Gull River Formation).

4 ROCKCLIFFE FORMATION
Limestone and shale

LOWER ORDOVICIAN

3 BEEKMANTOWN GROUP
Dolostone, sandstone

CAMBRO-ORDOVICIAN

2 POTSDAM GROUP
Sandstone

PRECAMBRIAN

1 Precambrian rocks

NOTES

a Includes Onondaga Formation in Niagara Peninsula.
b Dolostone predominates on Manitoulin Island.
c Formations in Ottawa area.

SOURCES OF INFORMATION

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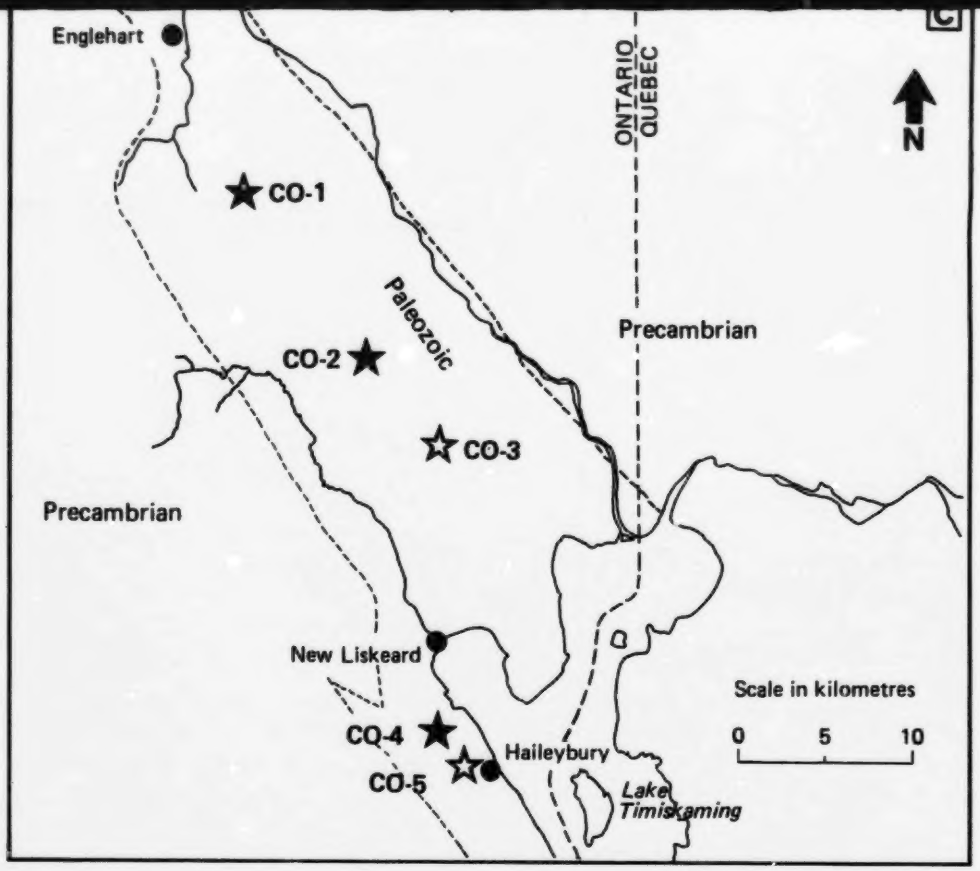
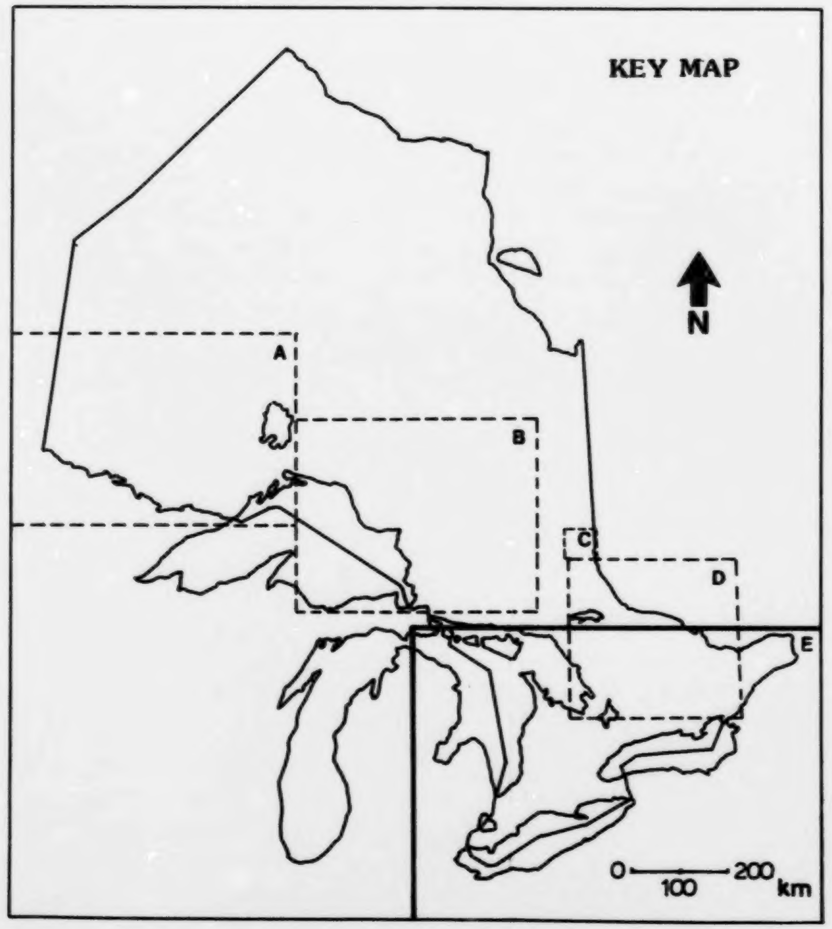
Geology from maps of the Geological Survey of Canada and the Ontario Geological Survey.


C
Englehart
ONTARIO
QUEBEC
N
CO-1
CO-2
Paleozoic
Precambrian
CO-3
Precambrian
New Liskeard
CO-4
CO-5
Haileybury
Lake Timiskaming
Scale in kilometres
0
5
10


KEY MAP
N
A
B
C
D
E
0
100
200
km

| DORMANT | ACTIVE | |
|---|---|---|
| □ | ■ | Marble |
| ▽ | ▼ | Calcite Vein |
| △ | ▲ | Carbonatite Complex |
| ✣ | + | Marl |
| ☆ | ★ | Limestone/Dolostone |

LEGEND OF DEPOSITS

| | |
|---|---|
| NO- 1 | Hahn Lake marble |
| NO- 2 | Woman Lake Narrows marble |
| NO- 3 | Gaherty Island calcite |
| NO- 4 | Kawashegamuk calcite |
| NO- 5 | Surprise Lake marble |
| NO- 6 | Wabikon Lake marble |
| NO- 7 | Cooke Point marble |
| NO- 8 | Eaglehead Lake marble |
| NO- 9 | Itren Lake marble |
| NO-10 | Shillabeer Creek marl |
| NO-11 | Neepatyre Mine calcite |
| NO-12 | Spar Island calcite |
| NO-13 | South McKellar Island calcite |
| NO-14 | Gravel River calcite |
| NO-15 | Prairie Lake carbonatite |
| NO-16 | Cargill carbonatite |
| NO-17 | Firesand River carbonatite |
| NO-18 | Spanish River carbonatite |
| NO-19 | Parkin Township calcite |
| NO-20 | Hagerman Township marble |
| NO-21 | Spence Township marble |
| NO-22 | Lount Township marble |
| NO-23 | Rutherglen marble |
| NO-24 | Whitney Property marble |
| NO-25 | Canada Talc Industries marble |
| NO-26 | Hungerford Township marble |
| NO-27 | Chromasco Limited marble |
| NO-28 | Steep Rock Calcite marble |
| CO- 1 | Nortario Limestone |
| CO- 2 | Township of Harley |
| CO- 3 | Hanbury |
| CO- 4 | Dymond Clay Products |
| CO- 5 | Farr |